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EPONYMS.

BY SIR D'ARCY POWER, K.B.E., LONDON.

XIII. SYME'S AMPUTATION.

THE history of amputations has still to be written. It will not be very long, because until the introduction of anæsthesia the simplest and quickest method was the best both for the patient and the surgeon: for the patient because he underwent the operation with a minimum of pain, and for the surgeon because he could the more easily control the bleeding and there was less tissue to suppurate. Circular amputation, therefore, was the accepted method, though a few brilliant operators used flaps; but even they fashioned them by transfixion and removed the limb at the traditional 'seat of election'. Amputation wounds rarely if ever healed by first intention, so that no stump was weight-bearing, and the majority were tender and irritable for years afterwards. 'The seat of election' was that point in the limb where the end of the stump was most protected and least in the way. The method was wasteful, because it led to unnecessary sacrifice of healthy tissues, and Syme introduced his operation with the statement that "it may be startling, but it is nevertheless true that amputation at the ankle-joint with hardly any exceptions may and ought to supersede amputation below the knee. The idea of amputating at the ankle-joint is not new, the operation having been performed on the Continent by different surgeons before I thought of it; and it would probably ere now have become generally adopted but for the doubt that was entertained as to the ends of the bones being sufficiently covered to afford the patient a useful and comfortable support for the limb. For my own part, when I read of dissecting flaps of skin from the instep or sides of the foot, I felt so much distrust in the protection that could thus be effected against the injurious effects of pressure on a part so exposed to it, that I had no desire to try the experiment. But it occurred to me that by performing the operation in a different way all such objections might be obviated. This was to save a flap from the sole of the foot and thick integuments of the heel, by making a transverse incision and dissecting these parts from the os calcis, so that the dense tissues provided by nature for supporting the weight of the body may be still employed for the same purpose. Two trials of this

operation having proved satisfactory, I communicated them to the profession, and am glad to find that not only my colleagues in the hospital here but also the practitioners in other places have already acted upon this recommendation. The additional experience of my own practice now enables me to suggest some improvements in the mode of procedure—point out an error to be avoided—and verify the expectation formerly expressed as to amputation of the leg being hardly ever required.

"The best instrument for performing the operation is a large bistoury or small amputating knife. There is no occasion for a tourniquet, as the assistant has complete command of the vessels by grasping the ankle. In my first operations the flap was made unnecessarily long; and I feel confident that the following directions may be trusted for exactly determining its proper extent. The incisions across the instep and sole of the foot should be curved with the convexity forwards and exactly opposite each other. A line drawn round the foot midway between the head of the fifth metatarsal bone and the malleolus externus will show their extent anteriorly, and they should meet a little way further back, opposite the malleolar projections of the tibia and fibula. Care should be taken to avoid cutting the posterior tibial artery before it divides into the plantar branches, as in two cases where I did so, there was partial sloughing of the flap. If the ankle-joint is sound, the malleolar processes should be removed by cutting pliers; but if the articulating surfaces of the tibia and fibula be diseased, a thin slice of these bones should be sawn off. The edges of the wound should be stitched together and lightly dressed. When the cure is completed, the stump has the shape here represented (*Fig.* 1), being conical in form and having for its apex, or central point of pressure, the thick integument which covered the heel.

FIG. 1.

"In proceeding to consider the circumstances in which this operation may be performed, it seems worthy of notice that until a recent period, amputation of the leg was in this country generally resorted to for the removal of diseased bone, when the part affected extended upwards beyond the metatarsus. The operation of Chopart might frequently have accomplished all that was requisite, but unfortunately laboured under a prejudice which opposed its adoption. This was, that the extensors of the heel, being deprived of antagonising action, would point the stump downwards so as to render it useless as a support for the body. In 1829 I ventured upon this partial amputation of the foot, though there was no precedent for it in Edinburgh, in a case where removal of the leg had been proposed, with perfect success and without the slightest inconvenience of the kind anticipated. Encouraged by this result, I resolved to adopt the operation; and before long performed it six times with entire satisfaction. Since that time the operation has been established here and regularly practised in cases admitting of its application.

" Although the introduction of Chopart's operation considerably abridged the field for amputating the leg, there were still two situations in which caries frequently occurs, where it was beyond the reach of any partial removal of the foot. These were the joint between the astragalus and the os calcis and the ankle-joint itself. I was therefore led to think of contriving a method of amputating at the ankle-joint which might afford relief under such circumstances and afford the patient a comfortable stump."

The first patient operated upon was a boy, age 16, who was admitted, probably into Minto House, on Sept. 8, 1842, suffering from disease of the foot, which had suppurated and ulcerated in consequence of a twist which he had given it in walking about twelve months before. The second patient was " Dr. W.", a medical gentleman about 25 years of age ; who had been seen in consultation with Mr. Goodsir in the early part of 1843. Both cases did well, and Mr. Syme notes that it was unnecessary to make any counter-opening in the heel flap in the second case, because he had button-holed the heel flap in dissecting it from the bone. " The drain thus afforded has proved so useful by permitting a free escape to the discharge and allowing the edges of the flaps to unite throughout their whole extent, that I think its intentional establishment would always be advantageous." From this time onwards Syme performed the operation so frequently that in August, 1844, he had records of fourteen cases, eight in his own practice and six in that of others, and in no instance had there been a fatal result. Incidentally he mentions the ease with which the operation could be done owing to the recent invention by Robert Liston of the straight cutting pliers for bone, which he hoped would supplant the variously shaped saws previously in use.

It took some years before the new operation assumed its proper position. In 1862 a report was made upon the subject of amputations through the foot and the ankle-joint by a Committee of the Associate Medical Members of the Sanitary Commission of New York. The members of the Commission, which included Stephen Smith, Valentine Mott, A. C. Post, and W. H. van Buren, reported that " the stump after Syme's amputation is much better adapted for an artificial appliance than that resulting from either Chopart's or Pirogoff's operation." In 1873, Mr. Henry Hancock, in his work *On the Operative Surgery of the Foot and Ankle-joint*, after a very careful examination of the recorded cases expresses his most favourable approval of the operation and quotes the just and liberal criticism of Jules Roux, who, after performing the operation for the first time in 1846, said : " It appears to me that by this operation art modifies without changing the language of nature ; in fact, the malleoli being removed, the lower extremity of the leg affords a base of support which transversely exceeds that of the os calcis."

The operation continued to excite a considerable amount of attention and some criticism. In 1878 Dr. John A. Wyeth, of the University of Louisville, set himself to work upon the surgical anatomy of the tibio-tarsal region with special regard to amputation at the ankle-joint. He found that in eighty consecutive dissections not a single calcanean branch was given off by the posterior tibial artery before its terminal bifurcation, while in every one of the eighty dissections one or more good-sized calcanean arteries were derived from the external plantar, within one and a quarter inches of its

origin. "In eighty cases," he says, "the number of calcanean branches derived from the external plantar was two hundred and twenty-one, and every one of these was safely inside the line of incision in amputations at the ankle-joint, when that incision is not more than half an inch posterior to the axis of the leg, the foot being at right angles. In all cases articular branches are derived either from the posterior tibial or internal plantar or from both. In some exceptional cases the internal plantar gave off some small branches to the heel. The anterior flap is plentifully supplied by branches from the anterior tibial, especially the malleolar arteries. The anterior and posterior peroneal arteries distribute branches to the outer portion of the calcanean flap, but they are not large enough for the blood supplied by them to maintain the integrity of the calcanean flap, especially when their anastomoses are cut off by division of the posterior tibial or its plantar branches too near their origin."

The illustration is a reproduction of the original drawing which appeared in the *London and Edinburgh Monthly Journal*, 1844, p. 648.

THE RADIOGRAPHIC FEATURES OF URINARY CALCULI IN RELATION TO THEIR CHEMICAL COMPOSITION AND STRUCTURE, WITH SPECIAL REFERENCE TO RENAL CALCULI.

By H. P. WINSBURY WHITE, London.

I wish first to acknowledge my indebtedness to Dr. Lucy Wills, of the Pathological Department of the Royal Free Hospital, for carrying out the detailed chemical and microscopical examination of the twenty-four renal calculi which are discussed in this paper. I have also to thank Dr. Scott Williamson, Director of Pathological Studies at the London (R. F. H.) School of Medicine for Women, and Mr. Ulysses Williams and his staff at the Radiological Department of the Royal Free Hospital, for their collaboration. My thanks are also due to Miss Sibyl Widdows, Lecturer on Chemistry at the London (R. F. H.) School of Medicine for Women, who analysed several stones for me, and to Sir Arthur Keith, for his kindness in allowing me to borrow for radiographic purposes some of the calculi from the Museum of the Royal College of Surgeons. Finally, I am indebted to the members of the honorary staff of the Royal Free Hospital for permission to publish these notes.

RELATIVE OPACITY OF CALCULI TO RÖNTGEN RAYS.

A true comparison of the density of calculi can only be made by considering shadows of stones which are exposed together on one plate or film. To attempt to compare the relative opacity of objects submitted to the rays at separate times, with differing lengths of exposure, and perhaps with alternative apparatus, can only lead to confusing results. In looking through the literature of this subject, I have come across one instance where sufficient regard had not been shown to these points, with resulting wrong conclusions.

Certain principles have been established by various investigators with regard to the factors which influence the capacity of different bodies to absorb the Röntgen rays. Benoist states a number of laws, as follows :—

The specific opacity of a body for a given quality of X rays and for a standard measured thickness is independent of the physical state of that body. This means that the same transparency of a body will be obtained whether it is in a solid or a liquid state, or in an amorphous or crystalline condition.

The specific opacity of a body is independent of the method of grouping of its atoms or molecules.

The specific opacity is independent of the state of liberty or combination of atoms.

Finally, Arcelin quotes Benoist as saying that the specific opacity of a simple substance depends upon its atomic weight.

As a urinary calculus is generally composed of a variety of constituents, its opacity is therefore equal to the sum of the opacities of those constituents.

The following simple substances may be tabulated in their order of increasing density according to their atomic weights. The numbers represent the atomic weights:—

Hydrogen	1	Sodium	23	Sulphur	32
Carbon	12	Magnesium	24	Potassium	39
Nitrogen	14	Phosphorus	31	Calcium	40
Oxygen	16				

Similarly, combinations of these simple substances can be arranged in their order of opacity according to the sum of the atomic weights of the simple substances.

The reason why the soft parts of the body give so poor a shadow is because their general density is little different from water, and, above all, because they consist of organic combinations containing almost exclusively hydrogen, carbon, nitrogen, and oxygen, whose atomic weights are low. Arcelin arranged a number of urinary salts in their order of increasing density according to their atomic weights as follows: Ammonium urate; uric acid; sodium urate; magnesium urate; potassium urate; calcium urate; cystine; calcium oxalate; calcium carbonate; calcium phosphate.

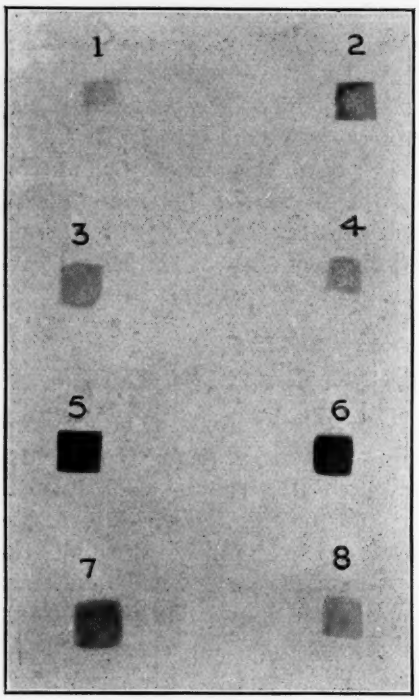

FIG. 2.—Portions of urinary calculi of equal depth, to indicate variations in opacity. 1, Uric acid; 2, Mixed urates; 3 and 4, Triple phosphate with trace of calcium; 5, Earthy phosphate; 6, Calcium oxalate; 7, Cystine with a trace of calcium; 8, Xanthine with a trace of calcium.

The order of the substances in the list is extremely interesting when studied in conjunction with a radiogram of calculi of known chemical composition. It must be borne in mind, however, that most urinary calculi are very composite structures with regard to the variety of their urinary salts. Nevertheless, it frequently happens that a stone consists sufficiently largely of one particular constituent to give some indication of the composition by radiogram. Again, the actual thickness of a stone will cause the opacity to vary. But, as Béclère points out, if two calculi are of different thickness, it is not necessarily that of greater depth which gives the denser shadow. The density will be in proportion to the sum of atomic weights of the different elements through which the rays pass. Further, Arcelin indicates that the actual structure of the stone has to be considered. Thus, a porous structure will cause a less dense shadow than a more compact one. He therefore lays

down that the opacity of a calculus is determined by: (1) The nature of its constituents; (2) Its structure; (3) Its thickness.

He took a number of calculi, reduced them all to a depth of 4 mm., and submitted them together to the same exposure of Röntgen rays. The stones were then examined chemically. As a result of his investigation he was able to arrange the following substances in the order given, which represents their relative opacity to one another, the first substance being the least dense: Uric acid; urate of calcium and of magnesium; ammonio-magnesium phosphate; phosphate of calcium and of magnesium; oxalate of calcium; phosphate of calcium. This order satisfies the laws of Benoist.

I have carried out similar experiments by cutting eight cuboidal pieces of stone, each 5 mm. in height, from stones previously chemically examined, in an endeavour to demonstrate the relative opacity of some of the constituents, most of which are common and a few rare. *Fig.* 2 represents a radiogram of these. The cubes have been cut small, as in this way there was more likelihood that they would have the same composition throughout.

It will be seen that uric acid gives the poorest shadow. It can barely be distinguished on the print. Calcium, so commonly present in urate stones as calcium urate, causes a greater density in No. 2 than is to be seen in No. 1. No. 2 has a fine line of calcium oxalate along its upper edge; but the rest of the cube may be taken as a mixture of uric acid and urates. Nos. 3 and 4, representing chiefly triple phosphate, owe their density for the most part to the presence of a small amount of calcium; when one considers the formula of triple phosphate, with its abundance of ammonium, a shadow of great density is not anticipated. Nos. 5 and 6, calcium phosphate and calcium oxalate respectively, give good shadows of almost equal density, that of the former being slightly more opaque than the latter. This is in conformity with the relative molecular weights. Cystine and xanthine, Nos. 7 and 8, give poor shadows compared with the two foregoing, but they also each contain a small amount of calcium.

OUTSTANDING PHYSICAL CHARACTERISTICS OF THE RENAL CALCULI UNDER INVESTIGATION.

Two separate groups of stones will now be considered. Each group comprises three photographs, as follows: (*a*) Stones before section; (*b*) Stones after section; (*c*) Radiogram of stones before section. *Group* I is shown in *Figs.* 4, 5, and 6; *Group* II in *Figs.* 12, 13, and 14.

It is not intended to go into a detailed description of all the physical characters of the stones. These features do not appear to be relevant to the purpose of this paper, and are difficult to appreciate from the photographs. The chief feature common to all the stones is that each occupied and developed in the pelvis of a kidney, and as in each case the pelvis was occupied by a single stone, we are dealing in no instance with two stones from the one kidney.

The actual size which any such calculus attains depends upon whether the excreting capacity of the kidney is destroyed at an early or at a late stage in the disease. For example, stone No. 7 of *Group* I, one of the smallest stones in the series, measuring one inch in its longest diameter, by giving rise

to back pressure and infection had caused every particle of excreting renal tissue to disappear, leaving only a fibrous shell. *Fig.* 3 shows the stone in the actual kidney. Stone No. 6 of *Group* I was removed from a kidney which was found to have a good deal of functioning tissue; the renal organ was therefore not removed, and has been carrying on its work fairly well for the past eighteen months without any recurrence of stone. Such examples as these should be a reminder of the difficulty in trying to assess the value of a kidney from the X-ray appearances of a stone which it contains.

FIG. 3.—Shows a small calculus in the pelvis of a kidney which has had all of its excreting tissue completely destroyed as a result of back pressure and infection.

The tendency is for the stone to form a cast of the larger channels forming the drainage system of the kidney, the building-up process being most active where the urine from the primary calices first comes in contact with the stone. Thus, commencing from a stone in the pelvis, a cast of this will first be formed, from which stems will project towards the main calices. How far the process will go will depend upon what stage is reached when the kidney ceases to function as an excreting organ, for at this point the stone will cease to grow. With one or two exceptions it will be seen that there is in each case a tendency for the formation of a central triangular-shaped portion. This occupied the kidney pelvis. The stones have been arranged so that the portion which projected into the ureter is directed downwards. There is one exception to this: in *Group* I, No. 10 is upside down in *Figs.* 4 and 6. In *Group* I, all of the stones except the rounded one show the calical process in some degree of formation—in some more than others.

Nos. 2, 6, and 12 of *Group* I show, in addition, casts of the secondary calices. No. 1 is a very unusual shape for a kidney stone, resembling more a vesical calculus. It developed in the already distended pelvis of a hydronephrosis; hence its rounded appearance. No. 6 of *Group* II has barely commenced to assume its triangular shape. No. 5 of *Group* I and No. 11 of *Group* II have a common characteristic in that the stem of each corresponding to the primary lower calix is well developed, and that the one corresponding to the upper has developed but slightly. There are two possibilities in explanation of these appearances. Either the stone was built upon the nucleus as it lay in the lower calix and eventually extended into the pelvis, or else the back pressure caused by the original stone in the pelvis destroyed the excreting tissue drained by the upper calix before that which drained into the lower, so that the building process could proceed in the lower calix long after it had ceased in the upper. The latter is the more acceptable explanation, because distention is always greater in the superior than in the inferior calix. This

point is also illustrated to a slight extent in Nos. 6 and 12 of *Group* I, where it will be seen that the casts of the secondary calices are more advanced on the lower stem than on the upper.

The colours of the stones are not to be appreciated in detail from the photographs, but a few points can be made out. The white or grey coat seen on some is all phosphatic. Stone No. 3 of *Group* I has a black coat consisting of laminated partly-organized blood-clot, which could be peeled off readily. No. 12, *Group* II, has also a black coat due to blood pigment. It is impossible to appreciate the true variations in shade of the other stones, which showed mostly different degrees of brown. The outer aspect of the cystine stone (No. 3, *Group* II) was light brown. The oxalate stones varied from dark straw colour to very dark brown or maroon, according to the amount of blood pigment incorporated. Most calculi have several kinds of salts in their composition, and it is only when certain salts predominate largely that the colour gives an indication of the chemical composition. Therefore the question of colour is not always of importance in indicating the nature of a stone, especially as a cross-section may reveal quite a different appearance beneath the surface.

In association with many of these stones were smaller ones lying in the dilated calices, and on handling some of the main calculi an indication of their existence is manifested by the presence of facets or small roughened areas from which portions of stone have been broken. These smaller stones may be few or many, and generally have the same chemical composition as the large stone in the pelvis. (*See Figs.* 7–11.)

These points can hardly be appreciated from the photographs, but are quite obvious on handling the specimens. In *Fig.* 5, Nos. 1, 2, 9, and 10, and in *Fig.* 13, Nos. 4, 6, 8, 11, and 12, each show a central portion different in colour from the main mass of the calculus built round it. This is the nucleus or first portion of the stone to be formed. In the remaining stones the nucleus is not clearly defined, because the urinary salts forming the original deposit have continued to form a considerable bulk of the stone.

THE CHEMICAL COMPOSITION OF INDIVIDUAL CALCULI IN RELATION TO RADIOGRAPHIC APPEARANCES.

The radiograms of the stones of *Groups* I and II (*Figs.* 6, 14) were taken before section of the stones, with the exception of No. 11 of *Group* I and No. 5 of *Group* II. The antero-posterior diameters refer to measurements of the central portions taken before division, No. 11 in *Group* I again being an exception.

GROUP I (*Figs.* 4–6).

No. 1.—Concentric lamination can be seen. In spite of the variations in colour, each stratum is principally composed of oxalate of lime, the variations in shade being accounted for by differing proportions of organic matter present. The diameters of this stone were 4 cm. transverse and 3·1 cm. antero-posterior.

The radiogram shows a shadow of considerable density, as would be expected after considering the foregoing remarks about this salt.

GROUP I.

FIG. 4.—Twelve stones, each removed from the pelvis of a kidney. All except No. 1 show evidence of the ureteric process and the two calical stems.

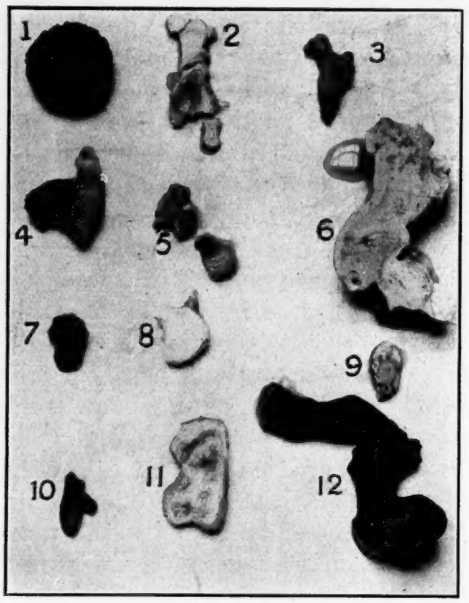

FIG. 5.—The stones of *Fig.* 4 cut to show their internal structure.

FIG. 6.—Radiogram of the stones of *Fig.* 4 to show the variations in opacity.

No. 2.—The small light oval area in the middle of the stone is the nucleus, and is composed mostly of uric acid with a little oxalate. In the surrounding darker area the salts are the same, but the proportions are reversed. The bulk is oxalate, uric acid being present only as a trace. The whitish portions forming the two stems consist of a mixture of calcium magnesium and triple phosphates. The latter salts indicate that ammoniacal decomposition of the urine eventually resulted. Antero-posterior diameter, 1·6 cm.

In the radiogram the nucleus can barely be distinguished as a small area faintly paler than the surrounding darker zone. This is, as one would expect, from the large proportion of uric acid present. The dark zone around this nucleus is clearly defined from the lighter shadows of the stems, the poor opacity of which is due to the large proportion of triple phosphate present. The darker areas at the extremities are due to the calcium present in the earthy phosphate in these situations. These features can be seen also in the clinical radiogram (*Fig.* 7).

FIG. 7.—Radiogram of large branched calculus in kidney. Differences in opacity of different parts of the calculus can be clearly made out. Two small calculi can be seen in the region of the middle calices. (See calculus No. 2, *Group* I.)

No. 3. — The cut surface shows as a fairly uniform dark colour. The lower end has been broken in cutting, and the laminated blood-clot seen on the outer surface dislodged. The nucleus is only faintly discernible on the right-hand margin just above the broken portion at the lower extremity. Antero-posterior diameter, 1·6 cm.

The radiogram is interesting. The bulk of the stone is barely visible, whereas the nucleus is more plainly seen as a small darker area towards the lower end, on the right-hand margin. The explanation of the difference in opacity is that the nucleus consists of uric acid and urates, with the latter in preponderance. In the rest of the stone the proportions are reversed.

The opacities of Nos. 3 and 2 should be contrasted, as they have the same antero-posterior diameters.

No. 4.—The cut surface shows the structure of the central portion to be maintained throughout a considerable bulk of the stone. There is no visible circumscribed small nucleus. It is a good example of a stone consisting of many constituents. It contains largely oxalate, a little calcium magnesium (earthy) phosphate, and a trace of uric acid. The upward projecting stem is of earthy phosphate. Antero-posterior diameter, 2·3 cm.

In the radiogram the main mass gives a considerable opacity, from the

large amount of calcium oxalate with the addition of earthy phosphate. The superior stem, of much smaller antero-posterior diameter than the main mass, consists of calcium magnesium (earthy) phosphate only. *Fig.* 8 shows the dense shadow of the clinical radiogram resulting from a stone of this size and consisting largely of the more opaque constituents.

No. 5.—The cut surface shows the pelvic portion to have the same appearance throughout. Chemically it was found to be a mixture of calcium magnesium phosphate and calcium oxalate. The downward projecting calical part has a dark and a light area in which two fine laminæ can be seen. The whole of this portion is a mixture of calcium oxalate and earthy phosphate. The dark area and the fine dark laminæ owe their colour to the presence of fibrin. Thus throughout the stone the same salts are found, but undoubtedly in varying proportions as shown by differing radiographic densities. Antero-posterior diameter, 1·6 cm.

FIG. 8.—Radiogram of large branched calculus *in situ*. Note the good density of the shadow, due to the presence of a large amount of calcium ; also note the small calculus in the lower calix. (See calculus No. 4, *Group* I.)

The radiogram clearly illustrates that contrast in colour does not necessarily represent contrast in inorganic constituents. In the clinical radiogram, *Fig.* 9, the variations in opacity can also be made out.

No. 6.—The cut section in the photograph shows a whitish surface more or less uniform throughout, as was also noted on the outer aspect. On inspecting the actual specimen, however, a large central mass in the pelvic portion is seen to be in contrast with the remainder. Chemically, the stone is unusual, the central portion being composed of cystine and xanthine. The rest is made up of triple phosphate with a small area of earthy phosphate. There is a trace of calcium throughout. Antero-posterior diameter, 2·1 cm.

The radiogram shows a poor opacity. This is to be expected in a stone of this composition. A narrow dark band about the middle indicates some calcium magnesium phosphate. The increased density of the stem projecting to one side at the lower part of the stone is due to the extra depth of the calculus here. There is no striking difference between the density of the central portion consisting of cystin and xanthine, and the rest made up of triple phosphate. *Fig.* 10, a radiogram showing the stone before removal from the patient, illustrates the poor shadow given by this large calculus.

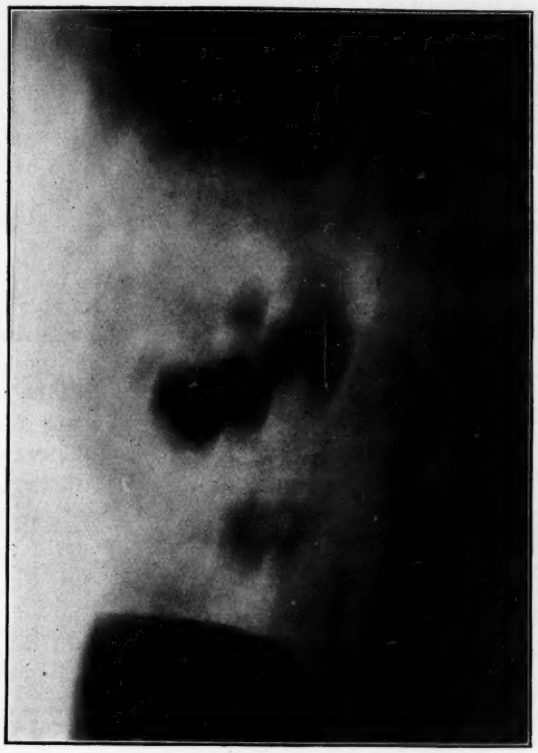

FIG. 9. — Radiogram of large calculus in kidney. It occupies the lower primary calix and the pelvis of the kidney. Small calculi are seen in the lower calices and the upper middle calix. Note the variations in opacity of the main stone. (See calculus No. 5, *Group* I.)

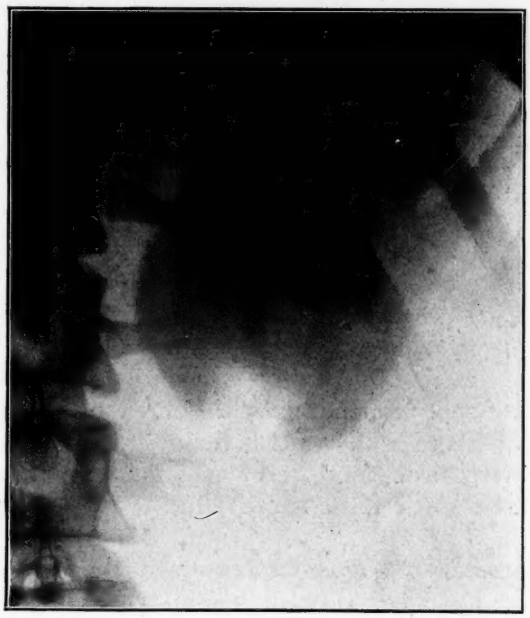

FIG. 10.—Radiogram of a large stone consisting of cystine, xanthine, triple phosphate, and a small amount of calcium. Note the poor shadow for so large a stone. (See calculus No. 6, *Group* I.)

No. 7.—The cut section shows a uniformly brownish colour throughout. Chemically, the stone consists of calcium magnesium phosphate and calcium oxalate with a trace of uric acid. Antero-posterior diameter, 2·1 cm.

The radiogram gives a shadow of good density, as would be expected.

No. 8.—The cut surface is shown as a uniformly white mass throughout. Chemical examination shows a composition largely of triple phosphate, with earthy phosphate in smaller proportion, but sufficient to give a good opacity in the radiogram. Antero-posterior diameter, 1·8 cm.

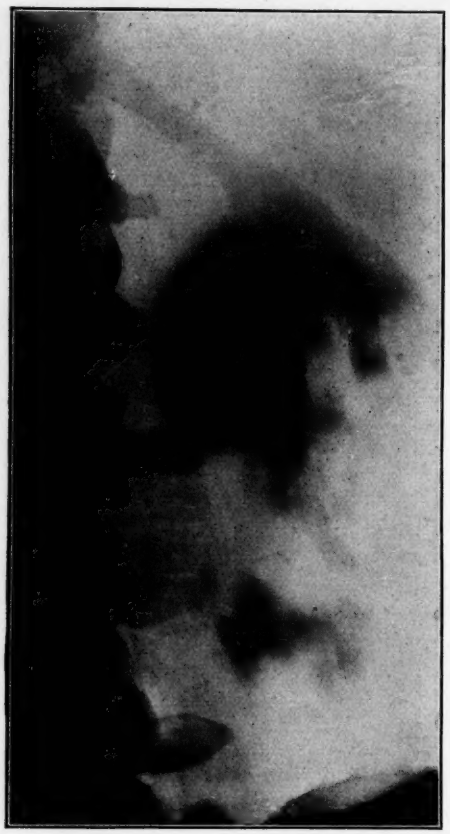

FIG. 11.—Radiogram of large renal stone, with many smaller stones. Good density on account of much calcium present as oxalate and phosphate. (See calculus No. 11, *Group* I.)

No. 9.—The cut surface shows a definite rounded central area occupying about one-third of the stone. The radiogram shows a nucleus as a light area surrounded by an irregular dark zone. Beyond this is the cortex forming an area intermediate in density. Chemically, the nucleus is uric acid and urates. The irregular dark zone is calcium oxalate, earthy phosphate, and uric acid. Obviously uric acid dominates in the nucleus, and calcium oxalate and earthy phosphates in the irregular dark zone. The cortex is earthy phosphate. Antero-posterior diameter, 1·4 c.m.

No. 10.—The cut section shows a sharp contrast between the oval light-coloured nucleus, and the dark surrounding cortex. Chemical examination of the nucleus gave uric acid and urates. The cortex consists largely of oxalate, with traces only of uric acid. Antero-posterior diameter, 1·3 cm.

The radiogram bears out the chemical findings, as the nucleus is seen as a central light area.

No. 11.—The cut surface shows the bulk of the calculus to consist of a large central whitish zone. The small irregular dark areas appearing in this zone are simply excavations due to portions broken away during the cutting. Surrounding this area is a dark lamina, and at the top of the stone there is a whitish mass superimposed. Chemically, the composition shows itself as a mixture of calcium magnesium phosphate and calcium oxalate. The thick dark band round the edge consists entirely of calcium oxalate.

The small antero-posterior diameter, 1·2 cm., explains why the shadow is so lacking in density. The stone had been divided before the radiogram was taken. The areas where portions have fallen away during the cutting

are seen as lighter zones. The clinical radiogram (*Fig.* 11) shows the dense shadow given by the greater depth of calcium oxalate present in the unsectioned stone.

No. 12.—The cut surface does not show clearly the variations in colour which are apparent on viewing the actual specimen, in which is seen a definite nucleus about half an inch in diameter and dark brown in colour. Throughout the remainder of the stone, definite laminæ of alternating light and dark bands are apparent. These are clearly seen in the photograph in the anterior of the two lower calical branches. Antero-posterior diameter, 2·2 cm. Chemically, the nucleus consists of a mixture of blood-clot, oxalate, and earthy phosphate. These constituents are contained throughout the stone, the dark laminæ owing their colour to the presence of fibrin.

In the radiogram the general density of the shadow is good. This would be expected from a mixture of oxalate and earthy phosphate. The laminations are also to be seen.

GROUP II (*Figs.* 12–14.)

No. 1.—The internal structure does not show any definite nucleus. Several small dark areas are due to pitting, indicating a somewhat porous structure. Chemically, the stone consists of calcium oxalate throughout, with some organic matter in the centre. Antero-posterior diameter, 1·9 cm.

The radiogram shows a good density.

No. 2.—The internal structure is uniformly grey. Chemically, uric acid forms the bulk, with a trace of urate and calcium oxalate, of which there is a thin coat round the edge. Antero-posterior diameter, 1·4 cm.

The radiogram indicates by the poor shadow the large proportion of uric acid. The oxalate on the edges is seen as a slightly darker band.

No. 3.—The cut surface, of a grey colour, has a somewhat porous appearance. There is no definite nucleus visible. Both microscopically and chemically, cystine was the chief constituent detected. There was a small amount of calcium throughout. The outer surface of the stone was light brown, and uniformly covered with a fine crystalline deposit of cystine. There were several large facets present, where articulation had occurred with smaller calculi. There were seventeen other cystine calculi present in the calices, ranging from 1 to 2 cm. in diameter. All were removed by nephrolithotomy from the left kidney of a female, age 32. Calculus No. 6 in *Group* I, consisting of cystine, xanthine, and triple phosphate, was removed from the right kidney of the same case a few months before. Antero-posterior diameter, 3 cm., one of the deepest stones in the collection. Length of stone, 6 cm.

The radiogram shows a fairly good central opacity on account of the depth and the presence of a certain amount of calcium, but towards each extremity, where the depth is less, the opacity is poor. The radiogram of the patient showing stones before removal from the kidney (*Fig.* 15) is interesting, as only a few of the smaller calculi can be seen, in addition to the main stone, which does not give a very good shadow. The radiograms illustrating the right and left calculi *in situ* do not necessarily indicate the true relative opacity of each calculus, as the length of exposure was probably different.

GROUP II.

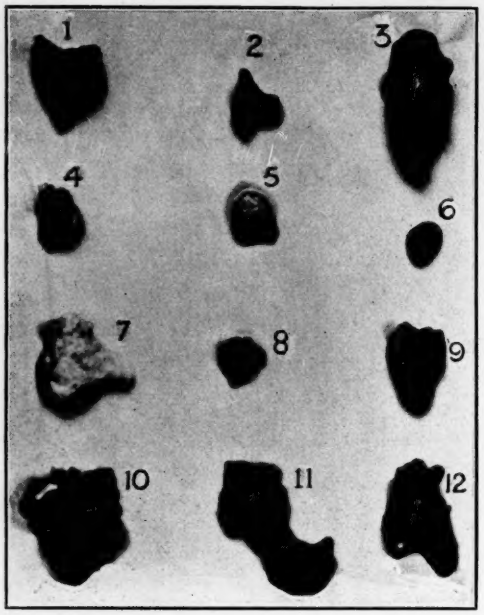

FIG. 12.—A second group of twelve stones each removed from the pelvis of a kidney. The characteristics of shape of such stones are to be noted in all except No. 6.

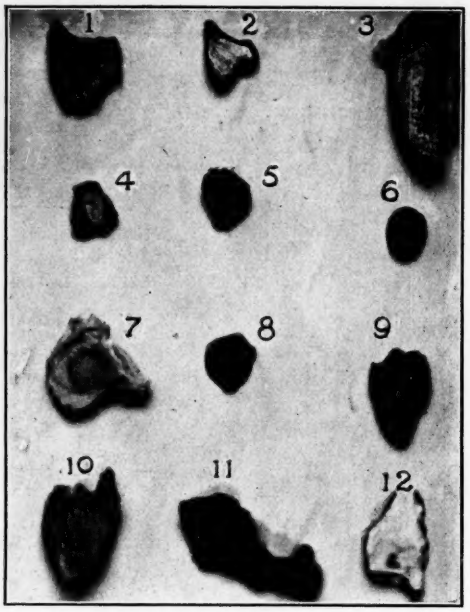

FIG. 13.—The stones of *Fig.* 12 cut to show their internal structure.

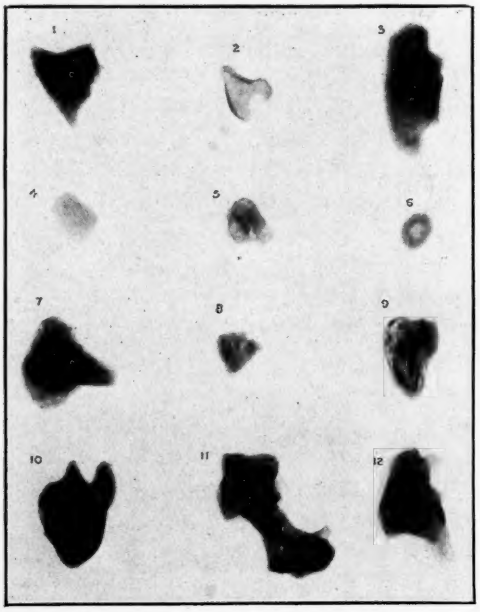

FIG. 14.—Radiogram of the stones of *Fig.* 12 to show the variations in opacity.

For the same reason the shadows in *Group* I cannot be compared with those of *Group* II.

No. 4.—Cross-section shows a large pale central area surrounded by a slightly darker zone. Chemical examination proves the nucleus to be a mixture of uric acid and earthy and triple phosphate. The outer zone is pure triple phosphate with organic matter. Antero-posterior diameter, 1·8 cm.

In the radiogram the nucleus shows clearly on account of the earthy phosphate present, whereas the outer zone can barely be distinguished, so poor a shadow does the triple phosphate give.

No. 5.—On section this is uniformly dark brown, with a fissure running from the lower border towards the centre, and several pits. A thin outer coat of grey is visible above and below. Chemical examination shows a mixture of earthy phosphate, calcium oxalate, and fibrin. In the main mass, the outer coat is mostly earthy phosphate with a little fibrin. Antero-posterior diameter, 1 cm.

The radiogram, representing one-half of the stone only, shows irregular variations in opacity, due to deficiencies and irregular distribution of the salts.

Fig. 15.—Radiogram of a large stone in pelvis of left kidney, with smaller stones in calices; eighteen stones in all were removed from the kidney. The smaller stones do not show in the radiogram. The stones consisted of almost pure cystine, with a little calcium. *Figs.* 16 and 15 are from a case of bilateral cystine stone in a woman, age 32. (See calculus No. 3, *Group II.*)

No. 6.—Cross-section shows definite pin-head nucleus, surrounded by two clearly defined circumscribed broad laminæ. Chemical examination shows that the nucleus and inner circumscribed area consist of uric acid and urates, the outer zone of calcium oxalate. Antero-posterior diameter, 1 cm.

The radiogram shows absence of opacity in the central area corresponding to the distribution of the uric acid and urates. There is not enough of the latter present to throw a shadow. The oxalate zone is well seen.

No. 7.—The outer surface is covered with a grey deposit. Cross-section shows a large central nucleus surrounded by a paler area and, finally, by the grey coating seen on the outer surface. On chemical examination, the nucleus was found to be largely calcium oxalate, with traces of urate and uric acid. Adjacent to the nucleus is a broad area consisting of a mixture of oxalate, and calcium magnesium and triple phosphates. The outermost zone consists of a mixture of earthy and triple phosphate and a little carbonate. Thus the stone contains all the common salts found in urinary calculi, and, by considering the composition of the three zones, it can be seen how the infective changes in the urine became more marked as time progressed. Thus, the nucleus

manifests no sign of gross infection; the adjacent zone, however, demonstrates that infection had supervened, as here the constituent (calcium oxalate) forming the bulk of the nucleus is found mixed with triple phosphate; while in the outermost zone there is no oxalate at all, but triple phosphate is found in abundance, with a little calcium carbonate. Large masses of phosphate may form very quickly in the presence of severe and persistent infection of the urine, whereas oxalate formation is very slow. Antero-posterior diameter, 2 cm.

The radiogram shows a considerable area of good density centrally, due to the larger amount of oxalate and earthy phosphate here. The outermost zone, most marked in the lower part, gives the poor opacity characteristic of triple phosphate.

No. 8.—The cut surface shows a uniform dark colour, as seen on the outer aspect. Chemical composition, calcium oxalate and a little blood pigment. Antero-posterior diameter, 1 cm.

The radiogram shows a fair amount of opacity, considering that the depth of the calculus was only 1 cm. Several linear light areas are to be made out; these are due to fissures in the stone.

No. 9.—The cut section shows a uniform dark surface without any evidence of a nucleus. There are several excavations. As regards its chemical composition, the bulk of the stone is mainly calcium oxalate, with a little earthy phosphate; there is an outer coat of earthy phosphate. Antero-posterior diameter, 1·8 cm.

In the radiogram, the irregular areas of poor density correspond with the excavations seen in the cross-section. The outer coating of earthy phosphate is only faintly seen, as it is very thin.

No. 10.—Cross-section shows a greyish surface, more or less uniform in appearance. Chemical examination shows that the stone consists almost entirely of calcium oxalate, except for some fibrin about the middle. Antero-posterior diameter, 3 cm.

The radiogram shows a very dense shadow, as would be expected from an oxalate stone of this depth. This shadow may with advantage be compared with No. 3 of this group, the cystine stone, as both have the same antero-posterior diameter. There is a striking difference in density.

No. 11.—The broadest portion of this elongated stone is the part which occupied the pelvis. The cross-section shows an elongated nucleus, surrounded by a rounded light area. The rest of the stone is uniformly dark brown. Antero-posterior diameter, 2 cm. As regards the chemical composition, the nucleus consists of urates, surrounded by blood-clot. The pale, somewhat rounded area encircling the nucleus is earthy phosphate. The dense area in the lower extremity is calcium magnesium phosphate and oxalate. The pale parts consist largely of triple phosphate.

The radiogram shows considerable contrast between the upper three-quarters of the stone and the lower quarter, which has a greater density.

No. 12.—Cross-section shows a clearly-defined small irregular dark nucleus, situated in a white zone, which is separated from the main mass of the stone by a thin dark lamina, outside which the white again prevails, being edged by a thin dark border. The chemical composition of the nucleus shows calcium

oxalate only. The surrounding zone within the darker lamina consists of a mixture of oxalate, and earthy and triple phosphate; beyond this, triple and earthy phosphate and calcium carbonate. Here, as in No. 7, there is evidence of progressing sepsis as the stone increases in size. Antero-posterior diameter, 2·2 cm.

In the radiogram, the more marked density of the central portion, due to calcium oxalate, disappears towards the periphery, as the oxalate and earthy phosphate are replaced by triple phosphate.

PREVIOUS INVESTIGATIONS OF THE CHEMICAL COMPOSITION OF URINARY CALCULI.

Much work in the past has been done on this subject. Most of the earlier observers considered uric acid and urates the most important constituent of urinary stones. But considerable differences in percentages have been recorded. To take a few instances: Thomson-Walker notes that out of 649 urinary calculi in the Hunterian Museum examined by Beneki, 74 per cent contained uric acid or urates. An inspection of the Hunterian collection of calculi in the College of Surgeons shows that the large majority are vesical stones. Dickenson examined 91 renal stones, and found uric acid or urates in 70 per cent. He also found oxalate of lime in 63 per cent. He quotes the findings of two other observers—Bence-Jones, who says that 75 per cent of all renal calculi are uric acid, and Roberts, who states that five-sixths are thus composed. Küster examined 511 renal stones; among the numerous constituents that he identified, he found uric acid or urate in only 3 per cent, oxalate in 22 per cent, and phosphate in 31 per cent; he found xanthine in 3 per cent; he was also able to identify iron and cholesterin in separate single stones, and indigo in 2. Ultzman, in 545 stones, found uric acid in 81 per cent, oxalate of lime in 5·6 per cent, and phosphate in 1·4 per cent. Morris, for 77 calculi, gives the following figures: oxalate of lime 44·15 per cent, uric acid 22·07 per cent, phosphate 16 per cent. Rosenbloom and Kahn, in a second series of 26 renal calculi examined chemically, found more than 60 per cent of oxalate in 66 per cent of the total, and smaller percentages in all of the remaining stones; even in two stones each having more than 90 per cent of uric acid, small amounts of oxalate were detected. The same two observers, in a previous report on 26 urinary stones, stated that the majority of these were composed of calcium oxalate. In this report there is no discrimination between kidney and bladder stones. Moore has examined 21 calculi from kidney or ureter, and found oxalate in over 70 per cent. Thus the conflict of figures goes on according to the numbers of observers we quote, but the later investigators have tended to find more oxalates than the older ones.

There are several possible explanations of the diversity of opinion: (1) The failure in some cases to quote separately the findings of bladder and kidney stones. Vesical calculi have greater proportions of uric acid and urate in their composition than have renal calculi. (2) In some instances one or more constituents have been sought without reference to others. (3) The inclusion of multiple stones from the same bladder or kidney in a series

submitted to examination would lead to a wrong conception of the relative incidence of the different salts in urinary stone, as multiple stones from the one source tend to have the same composition. They are relatively frequent.

SUMMARY OF CHEMICAL ANALYSIS OF STONES UNDER INVESTIGATION, AND CLINICAL SIGNIFICANCE OF CHEMICAL COMPOSITION.

These researches have added yet another series of figures to the literature of the subject, but agree with the results of the majority of modern observers in demonstrating the presence of a high percentage of calcium oxalate. Of the 24 renal stones investigated, it was found that 75 per cent contained calcium oxalate and 58 per cent calcium phosphate in considerable amounts, and for diagnostic purposes it is worthy of note that one or other of these salts of such good opacity to X rays was present in 91 per cent. In 66 per cent one or other of these salts was found in the central portion of the stone. This is of some importance when it is recalled that many stones give rise to the most severe colic when they are relatively in the nucleus stage, and detection by radiogram while so small will depend to a great extent on their chemical composition. In 11 stones (45 per cent) some proportion of uric acid was detected, and in all of these calcium oxalate or calcium phosphate was noted as well, so that with none of these stones did the presence of uric acid cause a serious danger that the stone would be overlooked in a radiogram.

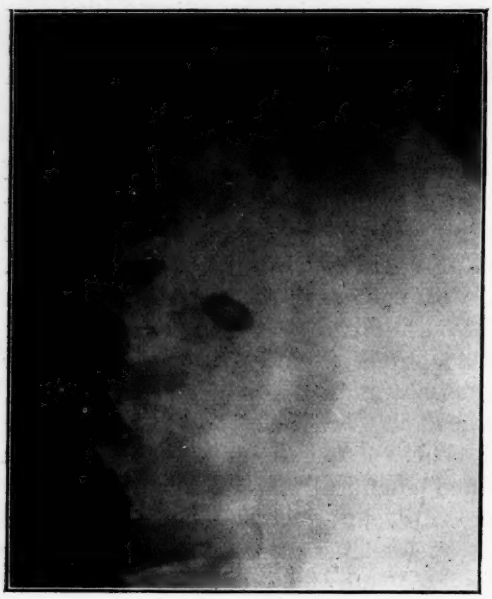

FIG. 16.—Radiogram of calculus in pelvis of kidney. The uric acid centre can be made out from the poor opacity.

There were four calculi (16 per cent) with a small nucleus consisting principally of uric acid, well defined as a clear central area in the radiograms, Nos. 9 and 10, *Group* I (*Fig.* 6), and Nos. 2 and 6, *Group* II (*Fig.* 14). These small masses could give rise to severe symptoms while still in the nuclear stage, and would be very difficult to identify by radiogram.

Six stones (25 per cent) contained urates in addition to uric acid. These salts also help in a slight degree to increase the density of the latter substance, owing to the frequent incidence of calcium urate, which gives a more dense shadow than the other urates. *Fig.* 16 shows a radiogram of a uric acid stone in the kidney pelvis coated with more opaque salts which enable it to be

identified. Of ammonium urate, which is less dense than uric acid, and the least dense of all the urates to X rays, Legueu says, "Usually the ammonium urate is mixed with urates of sodium, potassium, and calcium". *Fig.* 17 shows an ammonium urate stone in the kidney of a child, made evident in the radiogram by the presence of other salts.

Six stones, 25 per cent of the series, contained triple phosphate, in two cases with carbonate in addition. Thus in all there is evidence that gross infective changes had occurred in the urine. One would not have been surprised to find these salts mostly in the composition of the largest stones, but such a finding was not without exception. The largest stone (No. 12 in *Group* I) had none, and one of the smaller ones (No. 4 in *Group* II) had these salts actually in the nucleus, indicating severe infective urinary changes in the early stage of the calculus formation. In searching for information as to the opacity of triple phosphate, in one instance only could a reference be found stating that triple phosphate gave a poor shadow by radiogram. The majority of writers merely indicated that phosphate gave a good shadow. From a comparison, however, of their molecular weights, the relative difference in density is obvious.

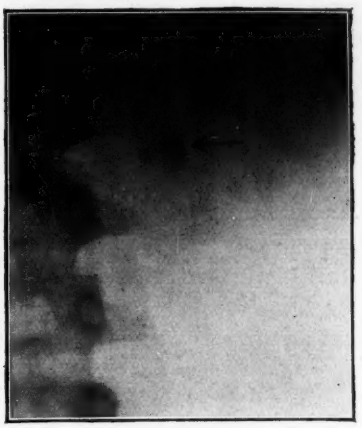

FIG. 17.—Radiogram showing ammonium urate stone in kidney of child. The opacity, which is poor, is due to the presence of a small amount of calcium.

With regard to the stones containing cystine and xanthine, they were both removed from the same patient. From the left kidney there were also taken a number of small cystine stones, and from the right a large branched stone consisting of cystine, xanthine, triple phosphate, and calcium carbonate.

CLINICAL ASPECT OF URIC ACID STONE IN KIDNEY, AND OF URETERIC CALCULUS.

For practical purposes it may be said that any large kidney stone will show on a good radiogram. But it must be borne in mind that though a pure uric acid kidney stone may be large, it will require skill and a good apparatus to demonstrate its presence, especially in a stout patient. Arcelin records with justifiable pride a personal triumph in identifying a pure uric acid stone, weighing 33 grm., forming a perfect cast of the pelvis and calices of the kidney, in a patient 25 cm. in depth. The shadow of the stone was of the same density as that of the kidney in which it lay.

The necessity for good radiography is, of course, more obvious in considering the presence of small stones. Legueu states that a calculus smaller than a pea cannot be expected to give a shadow. I have before me at the moment an oxalate stone 4 mm. × 3 mm., passed per urethram. This stone had previously been clearly identified in a radiogram in the pelvic portion of

the ureter. Arcelin is more correct when he says that pin-head calculi of any composition cannot be identified.

The smaller stones often pass quite silently. Small rough stones, by causing congestion of and injury to the mucous lining of the ureter, are more liable to give rise to symptoms than smooth stones of the same size. Many oxalate stones are perfectly smooth, and may pass as quietly as those of uric acid of a similar size. The majority of oxalate stones, however, have a rough exterior, and even very small ones are apt to give rise to hæmaturia, if not to colic, while passing down the ureter.

It is doubtful if an oxalate stone large enough to set up colic could not be identified by radiogram; but there are numerous examples of colic due to a ureteric calculus not to be detected in this way. Graves published an instructive case in which an ordinary radiogram had been negative, but a ureterogram demonstrated a clear area in the lower end of the ureter about the breadth of, but a little shorter than, a date-stone. The stone was passed per urethram a few days after the examination. It must not be forgotten, however, that the symptoms often considered typical of stone can be exactly simulated by other diseased conditions of the kidney or ureter.

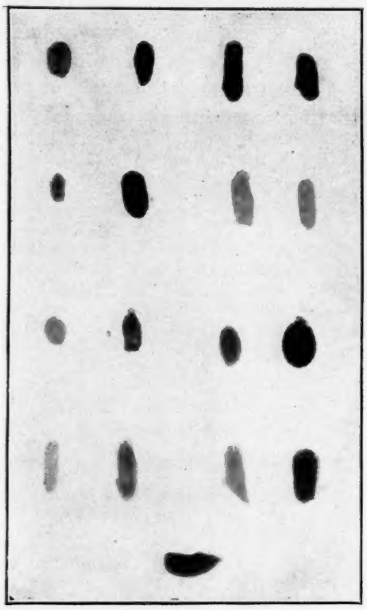

FIG. 18.—Radiogram showing contrast in shadows of stones containing good proportions of calcium, with uric acid stones. The majority are ureteric stones, and the less dense ones would be difficult to identify in the ureter by radiogram. (*From the Royal College of Surgeons' Museum.*)

Chemical examination of ureteric stones reveals oxalates as the commonest variety. By ureteric stones is meant those which become impacted in the ureter. Marion has the following note: "The most frequent are oxalates, then carbonates and phosphates, then uric acid or urates, pure or associated with phosphates or oxalates".

From a comparison of bladder and renal stones, it would appear that more of the uric acid variety reach the bladder than do those of oxalate, and in many cases without an antecedent history of colic, and therefore often do not call for radiographic investigation. When, however, symptoms are present, with a negative radiogram, a criticism by Arcelin should be most helpful in deciding the question of surgical interference. He says that during a period of seven years, up to the time of writing, he had not known a surgeon explore for a uric acid calculus that had not been identified by X rays. It certainly has long been the custom for urinary surgeons to hesitate to perform exploratory operation upon a kidney or ureter for stone in the presence of a negative radiogram.

Fig. 18 is a radiogram of a number of calculi showing considerable differences in opacity. The majority are stones which formed in the ureter, as is indicated by the prevailing elongated shape. The uric acid stones are easily

picked out by their poor density, and it must be obvious that these would be extremely difficult to detect in a radiogram. It may be added, however, that none of these uric stones became impacted in the ureter; all eventually passed into the bladder.

VESICAL CALCULI.

GROUP III (*Figs.* 19–21).

Fig. 19 shows a collection of vesical calculi. Stones which lie free in the bladder maintain their characteristics of shape, as do renal and ureteric calculi. They are spheroidal, ovoid, or discoid.

A study of the large collection of vesical calculi in the Museum of the Royal College of Surgeons of England shows that in the majority uric acid and urate form a much larger bulk of the individual stones than they do of renal stones. It is not an uncommon experience to find in the bladder on cystostomy a stone of moderate size which was not revealed by radiogram. The identification by radiogram of many bladder stones, whose composition is largely uric acid or urate, is often due to the presence also of calcium in the form of earthy phosphate or oxalate.

Fig. 19 shows the large amount of phosphate present on the outer surfaces of many of the stones, all of which are from the bladder. The phosphatic deposit shows as a grey or whitish coat.

Edward Keyes, of New York, gives a table illustrating the results of radiography in a consecutive series of cases in which stone was present. The relatively large number of bladder stones not identified by radiogram indicates the greater proportion of uric acid in these: In stones in the renal pelvis there were 32 positive results, and 6 erroneously negative; in vesical stones 16 were positive, and 12 erroneously negative.

Group III shows three different photographs of a group of 28 or more vesical calculi, removed in a series of operations by various surgeons at the Royal Free Hospital. They are numbered from 1 to 28.

Fig. 20 is a radiogram of the stones shown in *Fig.* 19. Stones numbered 1, 2, 3, 4, and 7 give scarcely any shadows at all, and Nos. 6, 8–12, 17, 18 and 22 all give poor shadows, while Nos. 5, 13, and 24 show a better degree of density in parts. In the actual radiographic negative the two dense oxalate stones, Nos. 14 and 15, show small nuclei of poor opacity, and the same features can be made out in Nos. 20, 21, and 26. These points, however, cannot be appreciated from *Fig.* 20.

The poor opacity of all the stones mentioned is due to the presence of uric acid or urate. It is instructive to study *Fig.* 21, in which the nuclei of Nos. 14, 15, 20, and 21 are clearly seen.

The large amount of phosphate present surrounding a nucleus of different composition is seen in Nos. 18, 21, 23, and 25–28. More than 75 per cent of these stones commenced as uric acid or urate stones, and many of them continued to progress largely as such. Whether they all had their origin in the bladder or in the kidney is not known; but No. 5 certainly is of vesical origin, as its nucleus consists of a portion of a needle, clearly seen both

GROUP III.

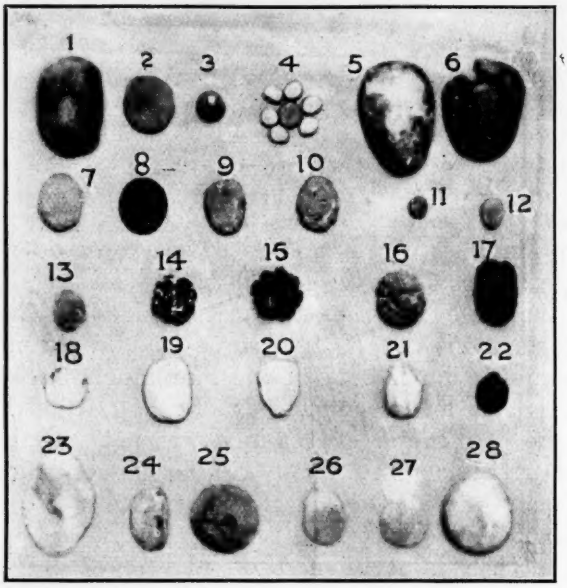

FIG. 19.—A group of vesical calculi. All tend to be rounded or ovoid. Many are covered with phosphatic deposit.

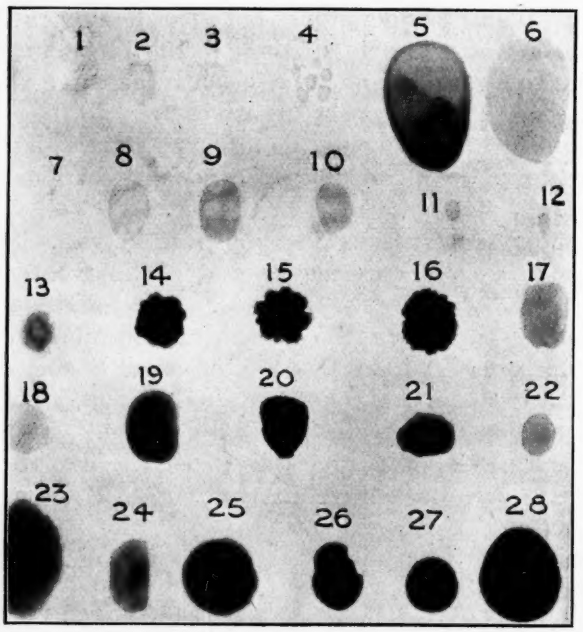

FIG. 20.—Radiogram of the group of stones shown in *Fig.* 19. Note the complete absence of shadow of many of the calculi, and the poor shadows of others. The poor opacity is due to the large proportions of uric acid and urates. A portion of a needle can be seen forming the nucleus of calculus No. 5.

GROUP III, *continued.*

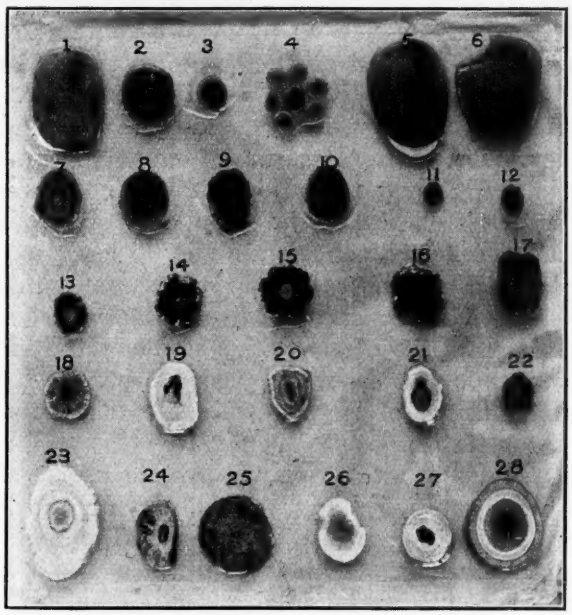

FIG. 21.—Photograph showing internal structure of stones in *Fig.* 19. The portion of needle can be seen in No. 5. The nuclei of many are well shown by contrast.

in the photograph and the radiogram. The darker portion of the stone indicates the presence of calcium phosphate, part of which was broken off as indicated by the light area.

THE DIAGNOSIS OF CYSTINE STONE.

Cystine and xanthine are worthy of some attention in considering their diagnosis by radiogram. According to the list of molecular weights, cystine lies in density between calcium urate and calcium oxalate. In the radiogram showing the cubes (*Fig.* 2) which formed part of the investigation, cystine occupies the same place with regard to opacity, but its shadow is much closer in density to that of the urate than to that of the oxalate, although it contains a little calcium. It would be quite wrong to say from this comparison that cystine gives a shadow almost equal in density to that of calcium oxalate. It undoubtedly gives a poor shadow, while the oxalate gives a good one. No doubt the sulphur present in the cystine molecule helps to increase its density.

In the earlier days of radiography it was held that a cystine stone was too transparent to the rays to be visible on a radiogram; subsequently, however, stones containing cystine removed by operation were shown to have been previously demonstrated by radiography. In all of these cases where the stones were submitted to chemical analysis, a certain amount of inorganic

matter, in addition to sulphur sufficient to explain the density, was demonstrated. Henry Morris described a cystine stone in the bladder in a boy of seven. It was easily identified by X rays. Müller quotes a renal case of cystine stone where small cystine recurrences were revealed by radiogram. A phosphatic crust was identified on the stones in these cases. Holmes and Ruggles refer to cystine stone as giving a very dense shadow. Colgate Graves, of Boston, describes a case in which he removed a cystine stone from the pelvis of the kidney. The stone measured 1·7 cm. × 1·7 cm. × 1 cm., and was negative to an ordinary X-ray examination. The stone, however, was revealed by pyelography as a less dense area in the middle of a somewhat distended pelvis. There is an excellent illustration of the pyelogram.

There is no doubt whatever that many stones containing cystine show up perfectly well on a good radiogram, but this is due to the fact that calcium is so frequently present. In *Fig.* 18 the stone in the right-hand bottom corner is a cystine stone. It throws a very good shadow. It has been labelled cystine oxide. As a matter of fact it contains a fair proportion of calcium as well.

The clinical radiogram of the large cystine stone already discussed (*Fig.* 15) makes an interesting study. By observing the bony skeleton, it will be seen that the radiogram is a good one. The main calculus, which measured 6 cm. in length by 3 cm., is easily identified. In addition there were seventeen other calculi varying in size from a diameter of 1 to 2 cm. It will be seen that the majority of the smaller stones are not visible. The general truth that all big kidney stones can be demonstrated by radiogram is well illustrated. It may be said that only the small pure cystine stones should be difficult to demonstrate.

A comparison between the shadow of the large cystine stone, No. 3, and the oxalate stone, No. 10, in *Group* II is a fairly accurate demonstration of the difference in opacity of these two substances, as the two stones each have an antero-posterior diameter of 3 cm.

SUMMARY.

The relative opacity of calculi of equal depth depends upon the atomic or molecular weights of their constituents.

The opacity of a calculus is determined by: (1) The nature of its constituents; (2) Its structure; (3) Its thickness.

Calcium oxalate and calcium phosphate give very good shadows. They are very common constituents of urinary calculi. The high relative opacity is due to the high atomic weight of the calcium present in these salts.

All the other common urinary salts give relatively poor shadows. They include the urates, uric acid, and triple phosphate.

Cystine and xanthine also give poor shadows in the pure state, but of slightly more opacity than the foregoing owing to the sulphur they contain.

It is rare for any of the foregoing substances to be the sole constituent of a stone. This applies to cystine as well as the more common varieties. There is frequently calcium oxalate or phosphate present.

The figures of different observers giving the relative incidence of different

salts in calculi have frequently been conflicting. Recent observers, however, are agreed upon the preponderance of calcium oxalate in renal and ureteric stones, and of uric acid and urates in bladder stones.

Phosphate is found in larger proportions as a constituent of bladder stone than of renal stone. It frequently surrounds a nucleus of oxalate, or uric acid or urate.

Stones of uric acid or urate in the kidney or ureter soon become mixed with calcium salts, after which they can be identified by radiogram.

Exploratory operation for stone is rarely justified when a radiogram is negative.

Radiograms sometimes fail to demonstrate vesical calculi consisting largely of uric acid or ammonium urate. Where possible, cystoscopy should always be carried out for this reason.

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THE REPAIR OF LARGE ABDOMINAL HERNIÆ BY MUSCLE TRANSPLANTATION.

By KENNETH MACKENZIE, Auckland, New Zealand.

From the point of view of operative treatment, abdominal herniæ may be divided into two classes: (1) Cases in which, after free dissection, layers of sound fascial and muscular tissue can be sutured to close the gap; (2) Cases in which the defect is too great for the approximation of the margins to be possible, or in which the tissue around the hernia is not competent to bear the strain.

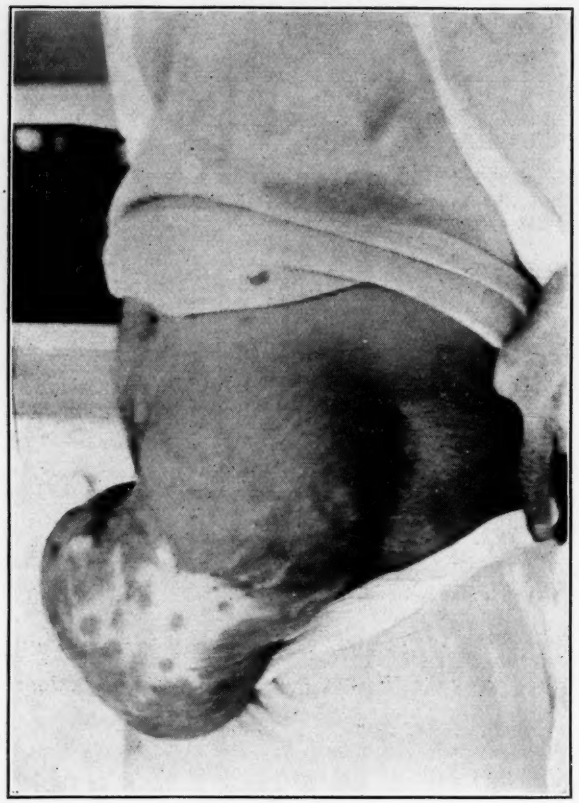

Fig. 22.—Large abdominal hernia; the case before operation.

This second class presents a difficult problem to the surgeon, and many solutions have been proposed. The introduction of the wire filigree was hailed with enthusiasm. It has given many excellent results, but there have also been many failures, either from disintegration of the filigree, or from the occurrence of even that minimum degree of sepsis which is fatal to the success of a metal implantation operation. The trend of surgery is away from the use of such material; hence trial has been made of animal tissue to close the defect. Massive free transplants of fascia lata have been used, or lacings with strips of fascia. For the better nutrition of the transplant, pedicled grafts have been used, especially in the upper abdomen, where large rectangular flaps of fascia have been turned down from the pectoral region. Ramlen-Hansen detached the sartorius muscle from the iliac spine, and carried it across the defect to a higher attachment on the abdominal wall.

My particular problem, for which none of the above methods seemed likely to be adequate, was a man 46 years of age, who received a severe

abdominal wound in the Battle of the Somme in 1916. The intestines protruded; there was much suppuration, and, in spite of numerous operations, fæcal fistulæ persisted until 1922. During these years an enormous hernia had developed (*Fig.* 22). The greater part of the wall of the left lower quadrant of the abdomen had been destroyed, and there was a circular gap, 5 inches in diameter, with its lower margin at Poupart's ligament and its inner margin nearly at the mid-line. The hernia contained almost the whole of the intestines. Many attempts had been made to support it with belts and bandages, but had failed, the more readily as the man had contracted a chronic bronchial affection.

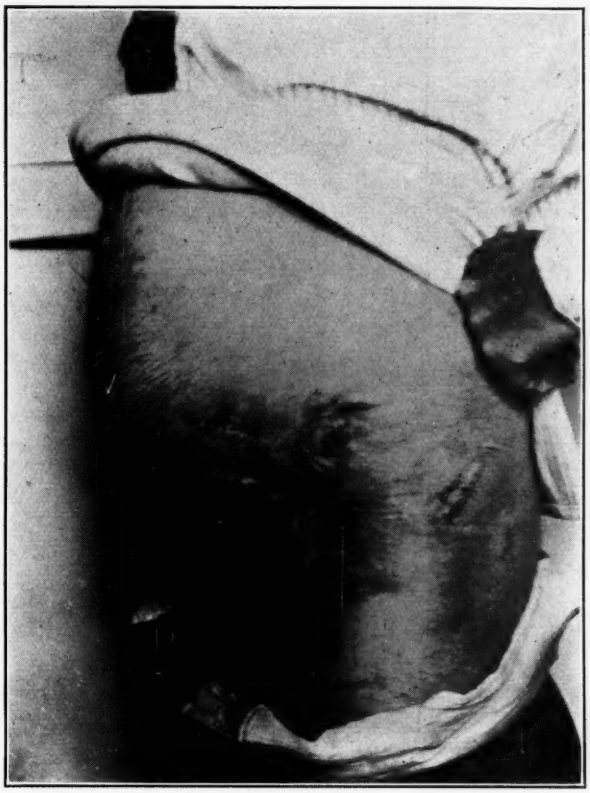

FIG. 23.—The same case ten weeks after operation.

Coaptation of the edges of the gap was out of the question, and it did not appear likely that a passive tissue such as fascia could bear the strain without stretching. A filigree was impossible in a wound in which infection was almost bound to be lurking.

The best chance, it seemed, was offered by the replacement of the abdominal muscle by other muscular tissue. A study on the cadaver showed that the tensor fasciæ femoris was the obvious muscle to use. Its upper attachment to the spine of the ilium is of small size, and this allows of the easy swinging of the muscle. The nervous and vascular supply enter the muscle very high up, and nerve and vessels, placed near the centre of swinging, are scarcely stretched when the muscle is in its new position. Lastly, the loss of this muscle is of small account to the limb.

The operation was performed under combined spinal and nitrous oxide and oxygen anæsthesia. A large mass of unhealthy skin was removed, and the margins of the opening were defined. The intestines were more readily replaced than had been anticipated. The peritoneal cavity was closed. A long vertical incision was carried down into the thigh. The tensor muscle was dissected free, with a margin of $1\frac{1}{2}$ in. at its lower end and rather less at its lateral borders, special care being taken to preserve the nervous and vascular supply. The muscle was swung forward and upward for a third of a circle, and filled the hernial opening, the fascial fringes overlapping the

adjacent abdominal fascia by fully an inch. The graft was fixed by numerous interrupted sutures of stout chromic gut. The gap in the investment of the thigh was narrowed as far as possible. A large rubber tissue drain was placed in the wound.

During the week after operation there was much trouble with cough. A small infection developed at the pubic corner of the wound, but remained localized and soon cleared up. At the end of a month electrical treatment of the transplanted muscle was commenced. At the end of six weeks the man

FIG. 24.—The same, ten weeks after operation.

was allowed up, and soon regained his activity. At the present time, four months after operation, the abdominal wall is sound, and there is every indication that a permanent cure of the hernia has been achieved. (*See Figs.* 23, 24.)

I suggest that this method can be used for the most advanced types of inguinal hernia, and for certain large post-operative herniæ in the mid-line below the umbilicus, in which the whole lower abdominal wall could be braced up by the use of the tensor muscle of each side, and the suture of their lower borders in the mid-line of the abdomen.

THE NUTRITION OF ARTICULAR CARTILAGE AND ITS METHOD OF REPAIR.

By LUKE KOKEN ITO, London.

THE NUTRITION OF ARTICULAR CARTILAGE.

Historical Notes.

Although Brodie, Bishat, Müller, Liston, and other older surgeons opposed this view, it is now generally acknowledged that articular cartilage in the adult is a non-vascular tissue. In 1742 William Hunter stated: "In the articular cartilage the blood-vessels are so small that they do not admit the red globules of the blood; so that they remain in a great measure unknown until the art of filling the vascular system with a liquid wax brought them to light." "Nor even by this method are we able, in adult subjects, to demonstrate the vessels of the true cartilaginous substance; the fat, glands, and ligaments may be red with injected vessels, while not one coloured speck appears upon the articular cartilage itself." Leidy pointed out the advantages of this non-vascularity of cartilage in securing its immunity from the many accidents to which a vascular tissue would be liable in a similar position where the parts are so much exposed to injury or irritation. Birkett, Redfern, Bart, Béclard, Cruveilhier, Meckel, etc., also believed in the non-vascularity of the articular cartilage.

In the past there were differences of opinion as to whether the free surface of the articular cartilages is invested by a reflection of the synovial membrane or not. Hunter stated that the perichondrium of the smooth articular cartilage is so fine and so firmly attached to the surface that there was "room for doubt whether it has been often demonstrated or rightly understood"; he raised a membrane in fairly large pieces after macerating, and found it to be a continuation of that fine, smooth membrane that lines the capsule of the ligament, folded over the end of the bone from the insertion of the ligament. Leidy failed to detect in the adult the slightest trace of synovial membrane on the free surface of the articular cartilages; he observed, however, that in the fœtal state it definitely exists, but after birth, in the progress of growth of the articular cartilages, it appears to be destroyed by pressure and attrition, and probably by the retirement of the surface vessels towards the circumference.

Todd and Bowman also believed that there is no synovial membrane on those parts of the articular cartilage that are exposed to pressure during movements of the joint. Toynbee believed that all healthy articular cartilage is invested with synovial membrane, which, however, differs from that met with elsewhere in that it is deprived of an epithelial layer. In one of Garrod's specimens Toynbee found a gouty deposit on the surface of the

articular cartilage covered by a fine synovial membrane. Henle described a delicate layer of cells (perichondrium) upon the actual free surface of the articular cartilage. Davis, Strangeways, Timbrell Fisher, and others, however, have confirmed the fact that in the main part there is no membrane on the articular cartilage.

In conclusion, it is generally believed that in the adult the lateral area of the articular cartilage is covered with a delicate extension of the synovial membrane; the central area, on the other hand, is completely deficient in any membrane or epithelial layer.

Whence, then, does articular cartilage derive its nutriment?

William Hunter believed that the articular cartilage derives it from the circulus articuli vasculosus described by him. Bart stated that in the adult it is principally nourished by fluid exuded from the vessels of the underlying cancellous bone. In adult articular cartilage there can be demonstrated very minute canals, probably for the passage of nutrient fluids that otherwise in this dense tissue would permeate with difficulty. According to Bart, the free surface of the cartilage is nourished by liquor sanguinis exuded from the circulus articuli vasculosus.

Leidy held the view that, during development and growth, articular cartilage possesses an interstitial nutrition; but that, after the cartilage is fully formed, it is supplied by fluid that osmoses from the vessels beneath its attached surface, and from the circulus vasculosus at its circumference, and especially by the synovia upon its free surface; he stated that the synovia is particularly rich in albumin. By experiments on calves, rabbits, and pigeons he found that the articular cartilage is quite capable of imbibing the synovial fluid. Toynbee considered that the chief supply of pabulum came, in the adult, from lymph exuded from the blood-channels of cancellous spaces. Strangeways observed 'loose bodies' in the joints, and discovered by operation that continued enlargement went on for a long time, although the loose bodies were quite detached; he concluded, therefore, that the synovial fluid is an important source of pabulum. Timbrell Fisher concluded that the deeper strata of the articular cartilage are nourished in the manner described by Toynbee, that the central articular area is supplied by the synovial fluid, and that the remainder near the edges receives its nutrient supply from the circulus articuli vasculosus. Using Shattock's method of staining mucin pink with carbol-thionin, Timbrell Fisher demonstrated that the zone of matrix of articular cartilage immediately surrounding each cell group is stained pink, and that the pink zones branch and intercommunicate. He considered, therefore, that the articular cartilage receives nourishment from plasma percolating through the network formed by the more mucinous part of the cartilage matrix that surrounds the cell groups.

Experiments.

My own experiments, made under the guidance of Mr. Choyce in the Surgical Unit at University College Hospital, are as follows:—

Using rats or rabbits, I opened the knee-joint by an external longitudinal incision, and then removed from the condylar surface of the femur, where

the cartilage is uncovered by any membrane, either one or two pieces of articular cartilage, some with and some without portions of subjacent bone. I then left the detached piece or pieces free in the same joint cavity, and closed the joint by suturing the capsule and skin with human hair which had been sterilized by boiling in water. For comparison, in some cases a piece of bone taken from the tail of the same animal was substituted for the detached cartilage, and the latter was auto-transplanted into the subcutaneous tissue of the animal's back.

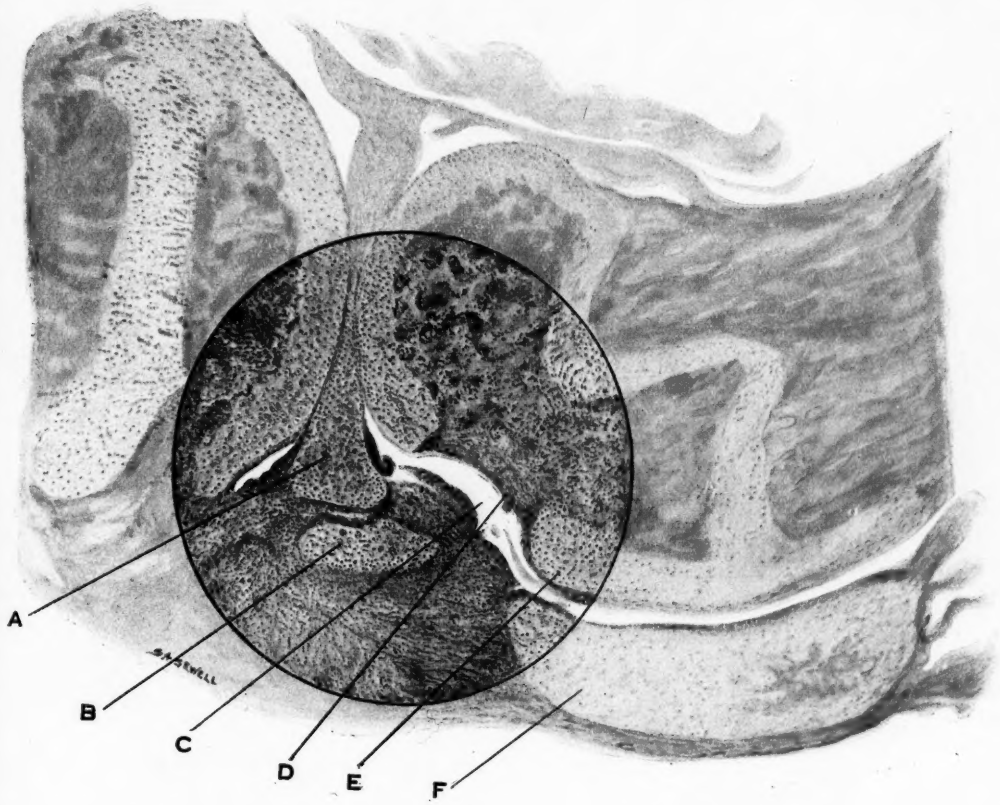

FIG. 25.—(*Experiment* 35). Examination 11 days after operation. A, Intra-articular cartilage; B, Loose body; C, Joint cavity; D, Defect of articular cartilage; E, Articular cartilage (original); F, Patella.

In another series of experiments a fresh whole knee-joint was transplanted into another animal of the same species; in still another a caudal vertebra together with its neighbouring joint was transplanted into the animal's back. The results of these control experiments will be reported later.

The results were observed after intervals that varied from one to fifteen weeks. The rats used were mostly young, or young adults, and approximately of the same age. Each specimen was fixed in 10 per cent solution of formaldehyde or Zenker's solution, decalcified in 5 per cent solution of nitric acid, followed by 1 per cent solution of sodium carbonate, and then thoroughly washed in running water. It was then embedded in paraffin

or celloidin and stained with Mallory's eosin-methylene-blue or alum-hæmatoxylin-eosin.

Only a few of the typical results are here described :—

I. Experiment No. 35.—Rat : age 45 days, male.

Method.—Rigid asepsis. Ether anæsthesia. Piece of articular cartilage detached from condylar surface of femur and left free in the joint cavity.

Examination 11 Days after Operation.—The detached cartilage was found in the synovial membrane between the anterior end of the intra-articular cartilage and

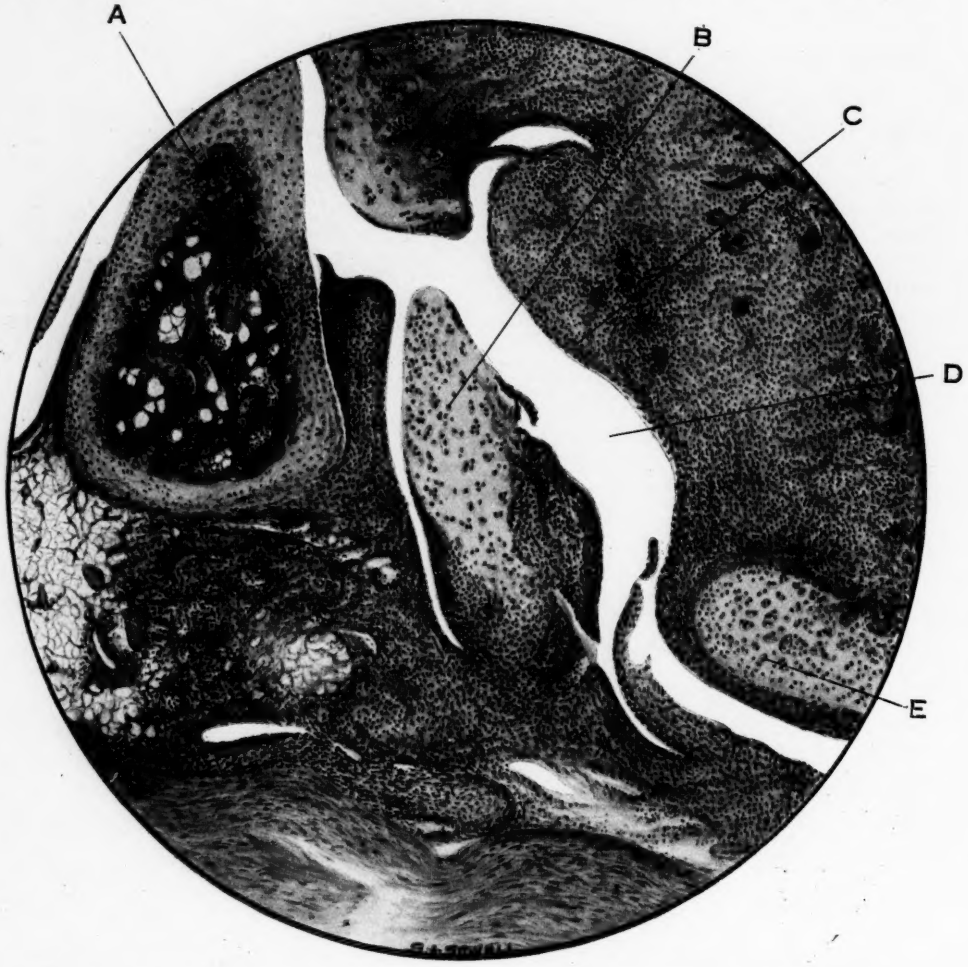

Fig. 26.—(*Experiment* 15). Examination 3 weeks after operation. A, Intra-articular cartilage ; B, Loose body ; C, Defect of articular cartilage ; D, Joint cavity ; E, Newly-formed cartilage.

the patella. It had become entirely surrounded by fibrous tissue, and the cartilage-cells had retained vitality, for they stained fairly well. No proliferative activity was seen. In this case no bone tissue had been detached. The defect on the condylar surface, caused by removal of the piece of cartilage, was found to have become lined with a layer of fibrous tissue, which intruded, more or less, into the bone-marrow. The bony tissue just below this fibrous tissue had lost activity, the bone-cells staining either badly or not at all. (*Fig.* 25.)

II. Experiment No. 15.—Rat: adult, male.

Method.—As in No. I, but with the detachment of some bone with the fragment.

Examination 3 Weeks after Operation.—The piece of cartilage was found partly wrapped in synovial membrane, and lying between the patella and the anterior part of the intra-articular cartilage; nearly half of it faced the joint cavity, and was free from covering membrane. The cartilage-cells in it stained well, but no bone-cells could be found, alive or dead. The cartilage defect in the femur was abundantly covered with fibrous tissue which contained many newly-formed blood-vessels; some fibroblasts were also seen scattered in the bone-marrow. In this fibrous tissue there was an area of newly-formed cartilaginous tissue. In the bony tissue around the njured area a little of the bone had lost its bone-cells. (*Fig.* 26.)

III. Experiment No. 31.—Rat: very young female.

Method.—As in No. II.

Examination 6 Weeks after Operation (*Fig.* 27).—In this case a detached piece of cartilage was found in connective tissue in the anterior part of the joint, near the patella. Not only had the original cartilage retained its vitality, but newly-formed cartilage could be seen. On the other hand, the bone-cells that had been detached with the cartilage had disappeared. The defect in the femoral cartilage was mostly covered with fibrous tissue, but in part with a tissue intermediate between cartilage and fibrous tissue, and to a small extent with a newly-formed cartilaginous tissue.

Fig. 27.—(*Experiment* 31). Examination 6 weeks after operation. A, Loose piece of cartilage in joint, near patella.

IV. Experiment No. 24.—Rat: young female.

Method.—As in No. II.

Microscopical Examination 7 Weeks after Operation.—The detached fragment was found half covered with synovial membrane, and half projected, uncovered, into the joint cavity. Both bone and cartilage-cells in it stained well. The femoral defect was repaired, in some part with newly-formed cartilage and in part with fibrous tissue; moreover, some tissue, transitional between cartilage and fibrous tissue, was seen. (*Fig.* 28.)

V. Experiment No. 23.—Rat: adult female.

Method.—As in No. II.

Microscopical Examination 8 Weeks after Operation (*Fig.* 29).—A fragment was located in the synovial membrane, partly attached to it and partly projecting free into the articular cavity. The cartilage-cells stained well: the original bone-cells had disappeared, but a slight new formation of bone-tissue could be found. The femoral defect was covered with a tissue that was mostly homogeneous, and no newly-formed cartilage could be seen.

VI. Experiment No. 18.—Rat: young male.

Method.—As in No. II.

Microscopical Examination 12 Weeks after Operation (*Fig.* 30).—The detached fragment was slightly surrounded with fibrous and fatty tissue derived from the synovial membrane, and lay just under the patella. The cartilage-cells in it showed staining activity fairly well, but their proliferative activity was doubtful. The

femoral defect was covered with a thin layer of fibrous tissue, directly covering the subjacent bone ; no cartilage could be seen in it.

VII. Experiment No. 20.—Rat : adult female.

Method.—As in No. II. This rat gave birth after operation.

Microscopical Examination 13 Weeks after Operation (*Fig.* 31).—The detached fragment was found in the popliteal part of the joint ; it had become pedunculated

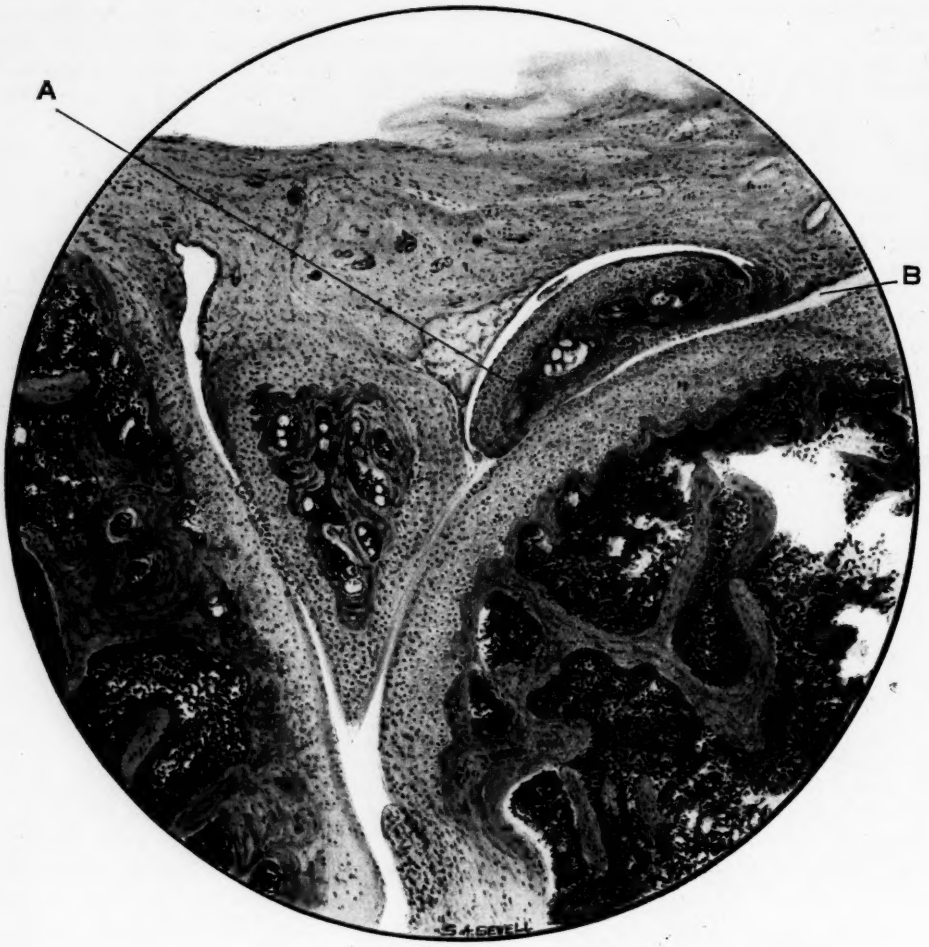

Fig. 28.—(*Experiment* 24). Examination 7 weeks after operation.
A, Loose body ; B, Joint cavity.

to the synovial membrane, and its whole mass had become covered with one or two layers of fibrous-tissue cells. Both cartilage-cells and bone-cells in the fragment stained well, though they were quite slight. The femoral defect was repaired with homogeneous tissue, newly-formed cartilage, and fibrous tissue.

VIII. Experiment No. 34.—Rabbit : young male.

Method.—As in No. II. Two pieces were detached.

Gross Finding 4 Weeks after Operation.—On opening the joint, two fragments were found. One was free in the joint cavity, the other was completely wrapped in synovial membrane. The former was smoothly rounded, almost oval-shaped,

and of the size of a rice grain ; the latter had maintained its original irregular form. A few drops of synovial fluid escaped ; in appearance it was indistinguishable from that of the healthy side. The defect in the articular cartilage of the femur showed piling up with a whitish, dense mass ; no adhesion was found.

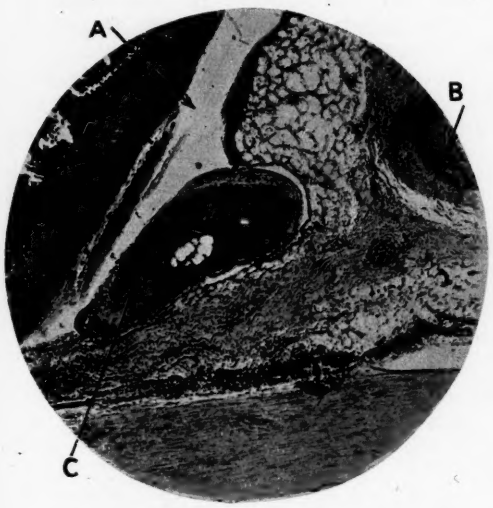

FIG. 29.—(*Experiment* 23). Examination 8 weeks after operation. A, Joint cavity ; B, Interarticular cartilage ; C, Loose body in synovial membrane.

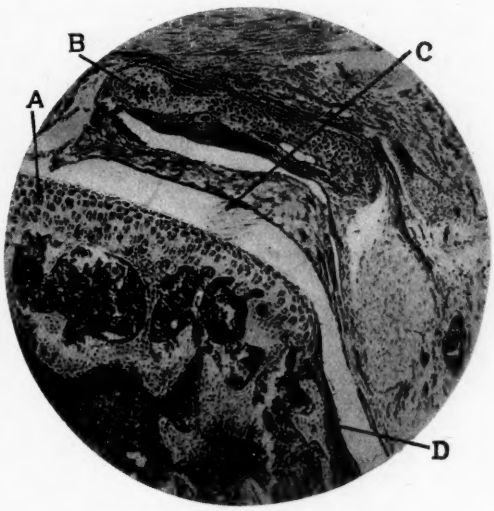

FIG. 30.—(*Experiment* 18). Examination 12 weeks after operation. A, Articular cartilage (original) ; B, Loose body ; C, Joint cavity ; D, Defect of articular cartilage.

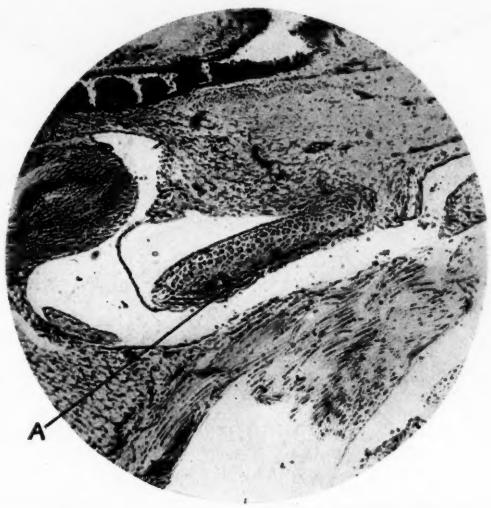

FIG. 31.—(*Experiment* 20). Examination 13 weeks after operation. A, Loose body.

Microscopical Examination (*Figs* 32–35).—

a. The fragment that was free in the joint : this was covered with thin layers of fibrous tissue. The original cartilage had maintained itself, but in certain places the cartilage-cells stained feebly and were of lowered vitality, and also there was well-marked new cartilage proliferation. The old bone-tissue had nearly lost its

bone-cells, but slight new bone-formation could be seen. The bone-marrow consisted mostly of fatty cells and red blood-corpuscles.

b. The fragment that had gained an attachment to synovial membrane: this was completely buried in the synovial membrane. In it the newly-formed bone-tissue was rather abundant, and the old bone, which had lost its bone-cells, was in small amount. The cartilage-cells stained well, but no evidence of new proliferation could be found. A small mass of dead bone, isolated from the above fragment, was detected in the fibrous tissue. The defect in the femur was repaired with the following structures: the superficial layer consisted of strongly developed fibrous tissue cells; the middle zone of tissue transitional between fibrous tissue and cartilage; and the deepest layer, in contact with the subjacent bone, was composed of

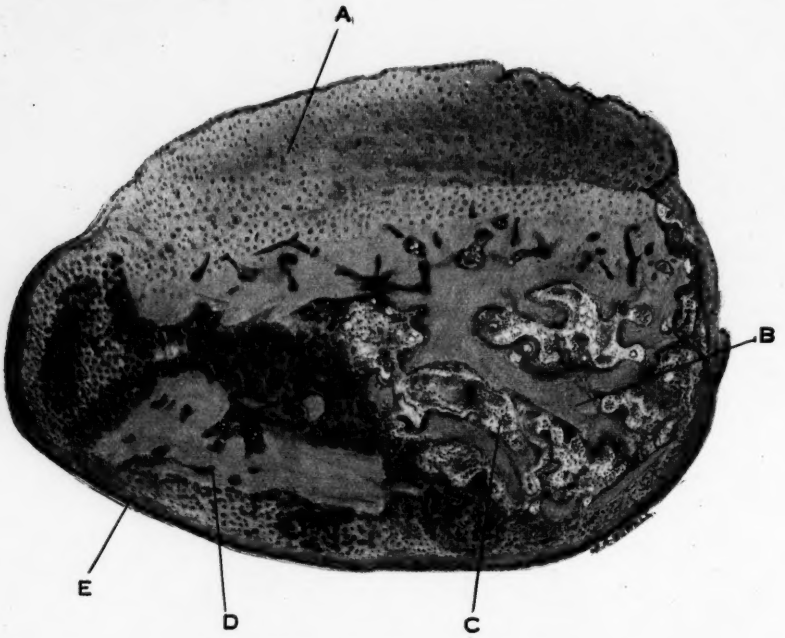

FIG. 32.—(*Experiment* 34). Young male rabbit: the completely detached loose body, 4 weeks after operation. A, Original articular cartilage; B, Newly-formed bone; C, Bone-marrow; D, Dead bone; E, Newly-formed cartilage.

newly-formed cartilage-cells. The bone-tissue just below the above structure showed proliferative activity better than in any other part. The whole repaired zone, at its greatest thickness, was nearly four times thicker than the surrounding undamaged articular cartilage.

SUMMARY OF ALL THE EXPERIMENTS, INCLUDING THOSE NOT DESCRIBED HERE.

Microscopical Examination.—The cartilage-cells in the loose bodies mostly retained vitality, and many proliferated; the bone-cells, on the contrary, became inactive and died; this agreed with Timbrell Fisher's results, and I believe that cartilage tissue is always more persistent than bone-tissue. After four weeks, however, newly-formed bone-tissue appeared round the dead bone in the loose bodies; this finding is confirmed by other experiments in which I transplanted pieces of the tails of rats, including bone and cartilage, into

animals' backs, and showed that, in almost all cases, new bone appeared after two weeks. As was expected, proliferative activity appeared greater in the younger than in the older animals.

With one exception the loose bodies were found to have gained a definite

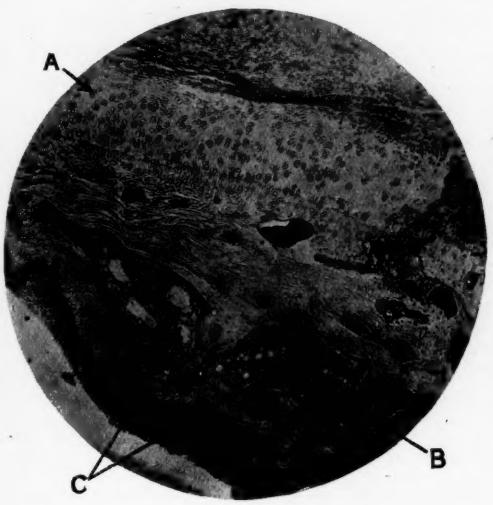

FIG. 33.—(*Experiment* 34). Examination 4 weeks after operation. A, Articular cartilage (original); B, Newly-formed bone; C, Bone-marrow.

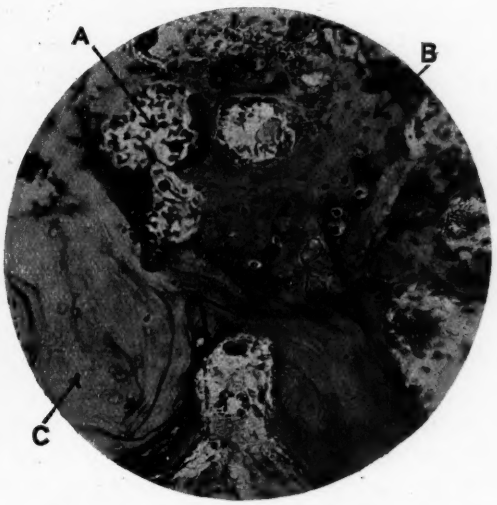

FIG. 34.—(*Experiment* 34). Examination 4 weeks after operation (higher magnification than *Fig.* 33). A, Bone-marrow; B, Newly-formed bone; C, Dead bone.

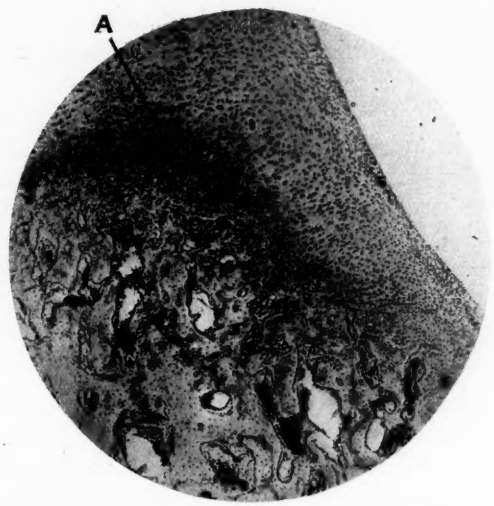

FIG. 35.—(*Experiment* 34). Examination 4 weeks after operation. The defect was filled with tissue and newly-formed cartilage. A, New cartilage.

attachment to the synovial membrane; some were almost embedded in it, others were affixed by edges and the whole of one surface, whilst still others had secured a pedunculated attachment. Some bodies that had been set free in the joint could not afterwards be found even by careful search. In

one case (a rabbit) only was the loose body found wandering free in the joint cavity; it had retained its activity. Most of the 'loose' bodies were found to have localized themselves in the synovial membrane of the anterior part of the joint, under or near the patella; one had become pedunculated in the popliteal space. The free one in the rabbit was particularly interesting, because, if it be assumed that it had remained free all the time between operation and post-mortem, it seems to prove that a piece of cartilage separated from all supply of pabulum except that derived from the synovial fluid can not only live but can proliferate; its bone elements had nearly disappeared, but there was slight new bone-formation; its cartilage had clearly proliferated. The question might justifiably be raised as to whether this loose body had been loose throughout the whole period between operation and post-mortem, or whether, like the others in my series, it had secured an attachment, which in this case had later been lost, so that the body again became loose. But careful examination of this body showed no evidence of any past attachment; its surfaces were uniformly smooth and showed no sign of the remains of a torn pedicle. It is therefore fair to assume that probably no such attachment had existed, or that, even if it had, the secondary separation had not been recent. As the cartilage-cells were quite active and there was some slight rejuvenescence of bone, vitality must have been active right up to the time of the animal's death, in spite of a separation that must have lasted much, if not all, of the time since operation.

Most of the other loose bodies had secured attachments to synovial membrane in the anterior parts of the joint, near the patella, though one was pedunculated in the popliteal space. These anterior parts of the joint are probably backwaters into which the loose body is worked during movements of the joint; in the small animals used, the relatively large loose bodies became jammed into these backwaters, and therefore, becoming motionless, there had an opportunity of securing attachment. If larger animals had been used, the loose bodies could have been cut relatively smaller; such smaller bodies would have had wider range of movements, would have been less liable to become trapped in corners, and would probably have remained free in a greater number of cases; it may be noted that the persistently free loose body was found in the only rabbit used; all the other animals were rats or mice.

The supposition that the completely loose body found in my rabbit had been nourished by the synovial fluid is, I think, a fair one, whether it is supposed that complete detachment had persisted since operation, or whether we believe that there had been a temporary attachment that had ruptured: moreover, it is in agreement with Strangeways' cases. The question whether the fluid was normal or not is not, however, so clear. Neither in my own nor in Strangeways' cases was an analytical comparison made between the synovia of the joint with loose body and its fellow without one. Timbrell Fisher's suggestion is that the loose body may cause sufficient synovitis to enrich the protein content of the synovia. However, the joint mouse in my rabbit was so relatively small and smooth and rounded that it probably caused but little trauma; and the synovia at post-mortem exhibited no difference in quantity, colour, or viscidity from that of the corresponding joint of the other limb; its total quantity was too small for analysis.

My experiment, therefore, is confirmatory of the belief that synovia can nourish loose articular cartilage; it may be presumed, therefore, that it has some nutritive function for unloosened articular cartilage, and that it may be an important factor in the nourishment of the superficies of cartilage near the centre of a joint, far removed from both circulus vasculosus and underlying cancellous bone.

REPAIR OF ARTICULAR CARTILAGE.

In my experiments the incisions for the removal of the pieces of articular cartilage all went through the thickness of the cartilage. The operative condylar defect so made healed by granulation tissue that became fibrous: this tissue invaded the underlying bone. Sometimes (e.g., *Experiment No.* 34, rabbit) it formed a heaped-up mass more than filling the gap. The tissue filling the gap in this case showed three zones, viz., fibrous on articular face, middle zone of intermediate tissue, and deepest zone of new cartilage cells. In another experiment (*No.* 37) cartilage was very freely formed.

EXPERIMENT No. 37.—Rat: age 45 days, male. *Method*.—Knee-joint opened; piece of articular cartilage, together with a portion of underlying bone, removed from the condylar surface of the femur.

Examination 4 weeks later (*Fig.* 36). —The defect was found to be smoothly filled with a whitish dense mass; there were no adhesions. Microscopic examination showed that the whitish mass largely consisted of newly-formed cartilage, but its surface was covered with fibrous tissue; there was also fibrous tissue between the new and the adjacent original cartilage. This new cartilage also protruded for a short distance into the subjacent bone-marrow; the development of new bone beneath it was insufficient.

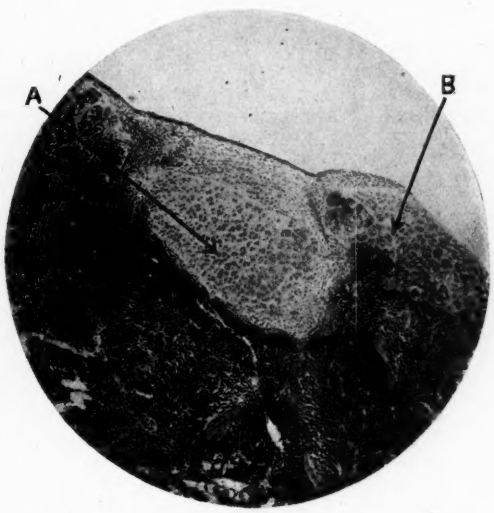

FIG. 36.—(*Experiment* 37). [Examination 4 weeks after operation. A, Newly-formed cartilage; B, Articular cartilage (original).

To sum up: The gap at first becomes filled with granulation tissue, which becomes fibrous, then fibro-cartilaginous, then cartilaginous. The time required for the formation of the cartilage varies: thus, *No.* 37 showed complete repair in the 4th week; *No.* 34 showed overgrowth by the same date; on the other hand, in some cases the repair material was still fibrous, without cartilage formation, as late as 12 weeks after operation.

Commonly in the rat the defect is filled with fibrous tissue by the end of the first week; after two weeks there is tissue transitional between fibrous tissue and cartilage, and after three weeks there are islets of new cartilage in the fibrous tissue. In some, the new cartilage was separated by fibrous tissue from the original cartilage, e.g., *No.* 37; in others it was continuous.

In the rabbit (*No.* 34) three zones, fibrous, transitional, and cartilaginous, were definite.

In some specimens it appears that the reparative tissue has come from the underlying cancellous tissue, in others transitional cartilage-like tissue seems to arise in connection with the edges of synovial membrane, if the injury to the articular cartilage has approached them. Redfern and Timbrell Fisher have shown that repair near the margins is good, but that nearer the centre it is poor, unless the underlying cancellous tissue has been exposed.

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A NOTE ON EXTERNAL DUODENAL FISTULA: WITH A RECORD OF SOME UNPUBLISHED CASES.

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An external duodenal fistula is a much-dreaded sequel to disease of, or injury to, this portion of the alimentary tract. It is fortunately of somewhat infrequent occurrence. A recent paper on this subject (Cameron[1]), with a review of the literature, refers to 30 cases, but there are doubtless many others unpublished. The writer of this article has had personal experience of 4 cases which have been in his surgical ward at the London Hospital during the last twenty years, and, from the hospital records during that time, a further 3 cases have been found, which have been placed at his disposal by the kindness of his surgical colleagues. One of the writer's cases (*Case* 1) has only recently left the hospital, and this short paper is based largely on the experience gained from this patient.

Etiology.—As one might expect, the majority of external duodenal fistulæ result from operative procedures, either upon the duodenum itself or on neighbouring viscera, especially the gall-bladder and kidney. Traumatic rupture of the duodenum (other than by a shot wound) is rare, and 'war' injuries have not been considered in this paper.

An analysis of 30 cases reported in Cameron's paper (loc. cit.) shows the etiology of the condition as follows:—

Duodenal Fistula Resulting from:—

Operation on the duodenum for—	Cases		Cases
a. Perforation of ulcer ..	6	Operation on the gall-bladder ..	6
b. Traumatic rupture ..	5	Operation on the kidney.. ..	7
c. Gall-stone in common bile-duct	1	Operation on the stomach ..	2
d. Carcinoma of the pancreas	1	Abscess in the loin	1
		Cause uncertain	1

The etiology of 7 cases occurring in the London Hospital surgical wards during the last twenty years is as follows:—

Duodenal Fistula Resulting from:—

Operation on the duodenum for—	Cases		Cases
a. Perforated ulcer	1	Operation on the stomach ..	2
b. Acute diverticulitis ..	1	Operation on the kidney ..	1
c. Traumatic rupture ..	1	Operation for appendix abscess ..	1

It appears from this short series that the majority of fistulæ in the duodenum are a direct result of operation for diseases of the duodenum itself (8 cases), of the right kidney (8 cases), or of the gall-bladder and bile-ducts, of which 7 examples are recorded; direct injury to the duodenum, treated by operation, is responsible for 6 cases, whilst operation on the stomach (4 cases), on the duodenum (cholecyst-duodenostomy) for carcinoma of the pancreas (1 case), appendix (1), abscess in the loin (1), and unknown cause (1), make up the remainder.

An external duodenal fistula occurring spontaneously, as a result of perforation of an ulcer and abscess formation, is very rare. One case has been recorded (Moynihan[2]).

It is significant that in the majority of these operations, as pointed out by Cameron, *gauze packing* was frequently used in addition to tube drainage.

Diagnosis.—The diagnosis of duodenal fistula depends upon the discharge from the wound of the characteristic duodenal fluid. This is usually bile-stained, but to a variable degree. It is viscid, alkaline in reaction, and may be discharged in enormous quantities. The amount discharged, however, varies considerably. It is difficult to measure the amount unless some form of permanent drainage apparatus is employed. In Cameron's case, quoted above, 700 c.c. were recorded daily, whilst in another patient (Erdmann[3]), no less than 4000 c.c. were collected in one day; subsequently, 50 to 60 oz. were discharged daily for eight days, after a jejunostomy had been made. It is easy to realize what a severe drain this must be on a patient enfeebled by a recent operation. On the other hand, the discharge in some recorded cases has been almost insignificant.

Next in importance to the actual amount is the irritating character of the discharge, and this again varies greatly. In some cases irritation of the surrounding tissues is hardly noticeable, whilst in others it is intense. Extensive burning of the skin, which causes agonizing pain, occurs, so that the constant dressings become almost unbearable.

Symptoms.—The symptoms caused by a duodenal fistula depend entirely on the amount and character of the discharge. In the ultra-acute cases, the rapidity with which a patient goes down-hill is most striking, and immediate operative treatment is urgently called for. Even the less acute cases, on account of the loss of sleep owing to pain, and progressive weakness from the constant dehydration, demand active surgical treatment if life is to be saved. In marked contrast are those where the discharge is scanty, does not irritate the tissues, and the symptoms are merely due to the discomfort of an occasional dressing.

Prognosis.—The accepted teaching that a duodenal fistula is an exceptionally grave lesion is mainly correct; but it is surprising to note how many have healed up, either with simple local treatment or as the result of some form of operation. Thus, in the 30 cases recorded in Cameron's paper, there were 18 recoveries. In 7 treated at the London Hospital between 1902 and 1923, recovery took place in all, and in 5 of these, healing of the fistula occurred without operation.

Prognosis as to the probable *duration* of the discharge depends on the amount and character of the fluid. Records show that, in the acute cases, death may occur in two or three days; in the less severe, discharge of fluid may cease after several weeks. In one remarkable case at the London Hospital (*Case* 5), under the care of my colleague, Mr. Russell Howard, an intermittent duodenal discharge had persisted for eleven years!

Treatment.—The treatment of a duodenal fistula depends upon the amount and character of the discharge and its effect upon the general condition of the patient. Operative treatment should not be considered at first unless urgent symptoms demand it. Local and general treatment alone may suffice.

LOCAL TREATMENT.—This consists in protecting the skin and, if possible, in some way preventing the discharge from coming into contact with the surrounding tissues. An ointment of oxide of zinc and castor oil, spread on lint, is useful; liquid paraffin has been successfully used in some cases. It is better not to employ either gauze or tube drainage. As the discharge is alkaline, acid solutions have been tried, but with little success and great discomfort to the patient.

Suction of the fluid has been employed with good results (Erdmann, Cameron). Cameron employed an electrical suction apparatus, but the constant noise of such an instrument prevents its employment in a general hospital ward. Erdmann drew off the discharge into a sterile bottle connected with a suction apparatus, and fed his patient through a jejunostomy opening with the duodenal secretions collected by this means! An ingenious frame, which enabled this to be done, is figured in an account of this case (loc. cit.).

A constant dilution of the discharge was successfully carried out in one case (Cheever), sterile water being used.

Cameron refers to two successful cases treated by Einhorn by means of his duodenal tube, but there are obvious limitations to this method.

GENERAL TREATMENT.—This consists in withholding fluid by the mouth as far as it is possible. Injections of saline and glucose should be administered by the rectum, and atropine may also be given as a means of lessening the amount of pancreatic secretion.

OPERATIVE MEASURES.—In the severe cases, some form of operation is imperative, in order to enable the patient to receive fluid, and so make up for the severe dehydration resulting from the continual discharge. The choice of operation rests between: (1) Gastro-enterostomy combined with occlusion of the pylorus (Berg[4]); (2) Jejunostomy; (3) Direct suture of the opening in the duodenum combined with either (1) or (2); (4) Direct suture alone.

1. *Gastro-enterostomy with Occlusion of the Pylorus.*—As treatment of a duodenal fistula, this was first suggested and performed by Berg. In 6 published cases, 4 recovered after this treatment: an immediate cessation of discharge followed in 3 cases. In the writer's patient (*Case* 1), the discharge decreased gradually for five days, and then a rapid improvement took place.

This treatment aims at cutting off the discharge of all stomach contents into the duodenum, thus removing the stimuli which encourage the flow of bile and pancreatic secretions. It has the great advantage that, within a few hours after operation, the patient can be given plenty of fluid naturally, and, after twenty-four hours, nourishment such as milk, eggs, Benger's food, etc. The chief disadvantage is that, in the already exhausted condition of the patient, such an operation may not be tolerated. Two cases reported by Berg proved fatal, although the discharge was efficiently checked. Another disadvantage is the obvious undesirability of short-circuiting a healthy stomach, a proceeding which may give rise to unpleasant sequelæ.

If Berg's method of treatment depends mainly on occlusion of the pylorus for its undoubted value in checking the duodenal discharge, it is difficult to explain how a duodenal fistula with much discharge can occur after a partial gastrectomy with closure of the first part of the duodenum. In Cameron's case (treated by suction) profuse duodenal discharge occurred after an anterior

Polya operation for cancer, and the careful record of this case seems to indicate that the discharge did come from the duodenum. A duodenal fistula (after partial gastrectomy) must be a very rare occurrence : notes of two cases only (Walton) were found in the London Hospital records up to date ; they are included in the list at the end of this paper The alternative hypothesis, that the fistula arose at the site of the anastomosis, is difficult to disprove, but is highly improbable.

2. *Jejunostomy.*—This operation, as an alternative method of introducing fluid, has much in its favour. It can be performed rapidly under local anæsthesia, and by improved methods in technique the fear of a permanent jejunal fistula should be negligible.

The choice of operative treatment usually rests between one or other of these methods.

3. *Direct Suture of the Opening Combined with Gastro-enterostomy and Closure of the Pylorus.*—One successful case (Souttar[5]) was operated on by this method at the West London Hospital in 1913. The patient, a girl, age 14, was admitted with a subhepatic abscess which was opened and drained ; a duodenal fistula followed the operation. Nine days later a second operation was performed ; an opening was found in the second portion of the duodenum ; this was closed by sutures. The pylorus was infolded by Lembert sutures, and a posterior gastro-enterostomy made. The operation was completely successful. The duodenal ulcer was probably the result of a severe burn sustained by the patient eighteen months previously.

4. *Treatment by Direct Suture alone* is tempting, but the results have not been encouraging. Mayo achieved a brilliant success in one case, but the operation was done immediately after the discharge was noticed, and probably the deleterious effect of the tryptic fluid on the tissues was not established. In all the other reported cases the sutures subsequently gave way, and this cannot be wondered at when one has observed the intense irritation to which the tissues are subjected.

ANALYSIS OF RESULTS.

Table I.—Simple Local Treatment : 13 Cases.

Case		Duration of Discharge	Result
1	Mayo ..	2 weeks	Died
2	Mayo ..	5 days	Died
3	Mayo ..	2 weeks	Died
4	Gardner ..	1 month	Recovered
5	Davis ..	12 days	Recovered
6	Palmer ..	8 days	Recovered
7	Hendon ..	5 weeks	Recovered
8	Stadler ..	1 month	Recovered
9	Author (*Case* 2)	3 months	Recovered
10	Author (*Case* 3)	1 month	Recovered
11	Author (*Case* 4) Operation by Huddy[6]	11 days	Recovered
12	Walton (*Case* 6)	9 days	Recovered
13	Walton (*Case* 7)	5 weeks	Recovered

Recovered, 10 cases ; died, 3 cases.

Table II.—Suction Treatment: 3 Cases.

Case		Duration of Discharge	Result
1	Palmer Irrigation	10 days	Recovered
2	Cameron ..	11 days	Recovered
3	Cheever Irrigation and Syphonage	Soon stopped ..	Recovered

Recovered, 3 cases.

Table IV.—Berg's Operation: 6 Cases.

Case		Duration of Discharge	Result
1	Berg ..	Ceased at once	Died: exhaustion
2	Berg ..	Ceased at once	Died: shock
3	Cameron ..	Ceased almost immediately	Recovered
4	Knaggs ..	Marked improvement ..	Recovered
5	Thénevard ..	Not stated	Recovered
6	Author (*Case* 1)	Immediate improvement, discharge ceased after 5 days	Recovered

Recovered, 4 cases; died, 2 cases.

Table V.—Jejunostomy: 5 Cases.

Case		Duration of Discharge	Result
1	Esau ..	Not noted	Died in 6 days from exhaustion
2	Winewarter ..	Not noted	Died 2 days after
3	Pannett ..	Short time	Recovered
4	McGuire ..	Immediate improvement, and closure in 3 weeks ..	Recovered
5	Erdmann .. + Suction	10 days	Recovered

Recovered, 3 cases; died, 2 cases.

Table VI.—Direct Suture (Alone or in Combination): 4 Cases.

Case		Duration of Discharge	Result
1	Mayo ..	Stopped at once	Recovered
2	Souttar + Berg's Opn.	Stopped at once	Recovered
3	Koerte ..	Sutures gave way 2 days later	Died
4	Fruwaengler + Berg's Opn.	Suture line leaked ..	Died

Recovered, 2 cases (1 simple suture); died, 2 cases.

CASES FROM THE LONDON HOSPITAL RECORDS.

Case 1 (AUTHOR).—**Traumatic rupture of duodenum; duodenal fistula.**

E. W., male, age 18. In October, 1923, the patient was playing Rugby football, was tackled, and fell forward on to the boot-heel of another player who was lying on the ground; the heel struck the patient in the epigastric region, and at the same time another man fell on his (patient's) back. He was helped up, but became unconscious for a few minutes. His abdomen was rubbed and he was able to walk off the field with help. He was sick, bringing up a little blood-stained mucus. When examined, an hour later, the pulse was 88. There was a bruise present over the upper part of the right rectus: no rigidity of the abdominal wall: no dullness in the loins: liver dullness present. Patient complained of severe spasmodic pains, and vomited repeatedly, chiefly mucus. He found lying on the right side the most comfortable position. His condition two hours later (7 p.m.) was much the same: there was no marked local rigidity or tenderness; still sickness; still spasmodic pain; $\frac{1}{6}$ gr. morphia given.

At 9 p.m. the pain was much better and vomiting had ceased. Well-marked bruise in the upper part of the right rectus, which now seemed somewhat rigid. Patient slept until 3 a.m., when the vomiting and pain recommenced.

Next day, at 10 a.m., the patient was found to have rigidity in the right side of the abdomen. Temperature 101°; pulse 100.

FIRST OPERATION.—At 1 p.m., Mr. Robert Going, F.R.C.S., of Littlehampton, opened the abdomen by a vertical incision to the right of the middle line, from the 'ensiform' to just above the umbilical line. The right rectus was retracted, and the posterior sheath opened. Later, to obtain more room, the rectus was divided transversely at the lower part of the incision. When the abdomen was opened, no free fluid was noticed at first. Emphysema was present in the gastrocolic omentum. The gall-bladder was full and adherent: some old adhesions between the gall-bladder and stomach were ligatured and divided. The gall-bladder was apparently intact. The first part of the duodenum was then examined. After separating some adhesions, what looked like a tear was found in the posterior peritoneum, close to the outer side of the second part of the duodenum; this was enlarged, and then *a small perforation in the duodenal wall* was seen: this was sutured, and the peritoneum and omentum were then sutured over it. The stomach was normal, the jejunum distended, the transverse colon normal and empty. Some bile-stained fluid was found in the right iliac region; this was swabbed out. A drainage tube was passed down to the renal pouch through a 'stab' opening in the right lumbar region. The lesser sac of the peritoneum was then explored: no fluid was found in it.

The patient became much collapsed, and the operation was finished quickly. The abdominal wall was sutured in layers. Patient rallied after a saline infusion: he had some post-anæsthetic vomiting. At 10 p.m. the pulse could be counted and was more regular.

Next day, Oct. 29, patient was much better: some bile-stained fluid escaped from the drainage tube: there was no abdominal distention. Patient improved during the day: the pulse became quite regular and he retained rectal saline injections.

Oct. 30. Patient steadily improved: no vomiting. Nutrients were given four-hourly and were retained: a small quantity of water was given by the mouth.

Oct. 31. General condition improving: had some feeds of milk and albumen-water.

Nov. 4. As the drainage tube appeared to be blocked, a stitch was removed and the tube altered in position: finally, it was removed and found to be blocked by a slough. A quantity of bile-stained fluid then came away: there was some infection of the incision in the right rectus. The bowels acted after an enema. In the evening a large quantity of fluid came away and escaped through the dressings.

Nov. 5. There was continued discharge from the tube: a large quantity of dark-coloured, viscid fluid escaped: this irritated the skin of the right flank, which

was deeply injected and acutely painful. The patient's general condition had changed for the worse. His eyes were sunken and he appeared much exhausted.

Nov. 6. Patient was sent up in an ambulance to the London Hospital, and seen by the writer the same afternoon, 6 p.m. The patient was evidently extremely ill. His eyes were sunken, his hands cold, and he was much exhausted. The tongue was dry and thickly coated. He did not complain of pain except when the wound was dressed. Below the ribs, in the right lumbar region, was a sinus with a drainage tube in it. The skin was intensely excoriated round this, over an area extending back in the right loin nearly to the spine: a large quantity of gelatinous-looking and slightly bile-stained fluid escaped. The dressings were continually soaked.

Temperature on admission 97°; pulse 100, small, very low tension; respirations 30. Rectal salines with glucose were ordered. As the patient was much exhausted by the long journey, it was decided to postpone operation until the next morning.

Second Operation, Nov. 7, 1923 (by the author).—The old incision was re-opened. Many adhesions were found to the right side of the abdomen: these were not interfered with. The stomach and first part of the duodenum appeared normal.

A posterior, no-loop, gastrojejunostomy was rapidly made, and the pylorus was then occluded by a purse-string suture of silk. A feed of beaten-up egg and peptonized milk was given (into the jejunum) at the time of the operation.

Nov. 8. The patient's condition was much the same, but he had rallied well from the operation: there was a little post-anæsthetic vomiting. He was able to take some fluid by the mouth; saline and glucose were given per rectum at intervals.

Nov. 9. The fistula was still discharging considerably: the skin round the orifice was raw and acutely painful: the dressings were soaked and required to be changed three times during the day and four times at night. He was taking a good amount of fluid by the mouth; at one time there appeared to be a little milk in the fluid escaping from the fistula.

Nov. 10. Patient propped up in a sitting position. He was looking better: his eyes less sunken. There was still a considerable discharge from the fistula, but patient was taking more fluid by the mouth, and also beaten-up egg, jelly, custard, etc. The skin was still very sore right round to the spine, although kept covered with emollient dressings. The discharge was alkaline, probably mainly pancreatic fluid.

Nov. 11 (4th day). Discharge appreciably less.

Nov. 12. Dressed only twice during the night; much less discharge on each dressing.

Nov. 13. Discharge quite slight: a very little thin fluid. Skin much less sore and inflamed: only one dressing required through the night.

Nov. 15. The patient's general condition was vastly improved. The eyes were not sunken, and he was sleeping and taking his food well. There was a very little discharge from the fistula: only one dressing was required every twelve hours. The skin round the fistula was rapidly healing.

Nov. 22. Fistula practically dry. From this date, patient made an uninterrupted recovery. The transverse portion of the abdominal incision gaped, but healed firmly by granulations.

Dec. 7. The patient was discharged from the hospital. Wound healed; general condition quite satisfactory. Pulse 82, temperature normal. Bowels acting normally.

He is in sound health at the present date.

Case 2 (Author).—F. H., female, age 39. A nephrectomy was performed at the London Hospital in 1910, for right pyonephrosis. The wound was drained for a time; it healed up slowly, and the patient left hospital two months later; she went to a convalescent home. Two days afterwards she complained of dragging pain in the right side, and vomited. The wound was opened up at the home; this

was followed by a sudden discharge of gas and a copious flow of thick yellow fluid tinged with green. Patient was re-admitted to hospital. The skin was much ulcerated and painful, and there was a free discharge of duodenal fluid from the wound. At one time, portions of an egg which had been eaten were found on the dressing. The discharge gradually became watery: it continued for two months and then ceased spontaneously. Her general condition at one time gave rise to anxiety. Treatment consisted in frequent dressings, and emollients for protection of the skin.

Case 3 (AUTHOR).—A. D., male, age 15. A case of appendix abscess, operated upon at the London Hospital in 1907. A large abscess of ten days' duration, tracking upwards towards the right kidney, was opened and drained with two tubes and gauze. The lower end of the kidney was palpable at the time of operation. The appendix could not be removed. The tubes and gauze were removed three days after operation, when a copious discharge of thin, sour fluid, containing bile, took place. The fluid irritated the skin: this continued for five days, and necessitated frequent dressings. The patient's general condition remained good, the discharge gradually lessened, and had completely ceased three weeks after operation.

Case 4 (AUTHOR).—Female, age (?). This case of acute diverticulitis of the duodenum was reported in the *Lancet*, 1923.[6] Operated on by Mr. G. P. Huddy, Surgical Registrar at the London Hospital. An inflamed and partly gangrenous diverticulum was found in the second portion of the duodenum, and was excised. Three days after operation, a discharge of brownish, watery fluid occurred. This was never profuse; the patient's condition gradually improved, and the wound healed fourteen days after operation. There was never any appreciable irritation of the edges of the wound.

Case 5 (MR. RUSSELL HOWARD).—G. B., male, age 66. A patient at the London Hospital in 1913. He had been operated on for a subhepatic abscess eleven years previously. A duodenal fistula, containing bile, resulted, and this had continued ever since. His general health was never much impaired, but the skin was always somewhat inflamed and the discharge was, at times, copious: it varied considerably from time to time. The patient at times plugged the wound and checked the discharge. When admitted to hospital, the patient was in good condition; the skin round the fistula was inflamed; the amount of discharge was not excessive, as the dressings had only to be changed three or four times a day.

Operation by Mr. Russell Howard. The abdomen was opened and a fistula was found opening into the first part of the duodenum. The duodenum was separated from the abdominal wall, and the opening closed by sutures. The abdominal wound was then repaired. The operation was completely successful.

The interesting features of this case are the duration of the discharge, and the ease with which the operation was performed; there was a surprising absence of adhesions in the operation area.

Case 6 (MR. A. J. WALTON).—H. S., male, age 54. This patient was operated on in the London Hospital in 1921 for carcinoma of the stomach. A partial gastrectomy was performed. The patient made a good recovery and left the hospital three weeks after operation. Next day a discharge occurred from the wound and he was re-admitted. There was a free discharge of alkaline, bile-stained fluid. Local treatment was adopted, and the discharge, which had never been excessive, ceased spontaneously nine days later. There was some irritation of the surrounding skin. The patient's general condition was good, and he is, at present, in sound health.

Case 7 (MR. A. J. WALTON).—C. S., female, age (?). Operated on at the London Hospital for a lesser-curve carcinomatous ulcer of the stomach. Partial gastrectomy was performed. The growth was adherent to the mesocolon. Twenty-three days after operation, a fistula developed, which persisted for five weeks. The discharged

fluid was bile-stained, faintly acid in reaction, and contained pus and coliform bacilli. The fistula slowly healed up. The patient was discharged from hospital in fair condition, but has since failed to report at the 'follow up' department.

CONCLUSIONS.

1. A duodenal fistula is a serious, but by no means fatal, condition.
2. In the less severe cases, simple local treatment may be tried.
3. In the acute cases, operative treatment is urgently called for, the choice lying between Berg's method and a jejunostomy.
4. Some form of suction apparatus is of much value from the nursing point of view, and adds greatly to the comfort of the patient.

I have drawn largely from Dr. Angus Cameron's excellent paper and careful record of the literature of this subject. My thanks are also due to Mr. Hamilton Bailey, F.R.C.S., my chief assistant at the London Hospital, for valuable help in the preparation of this paper.

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TRAUMATIC DISLOCATION OF THE HIP IN CHILDHOOD, AND RELATION OF TRAUMA TO PSEUDOCOXALGIA:

ANALYSIS OF 59 CASES PUBLISHED UP TO JANUARY, 1924.

By C. C. CHOYCE, London.

This condition is very rare, having only been previously recorded on fifty-three occasions, but attains interest because in several recent cases sequels have occurred many months after the primary accident. In two cases definite pseudocoxalgia has followed (Elmslie and Rehbein), although radiograms taken at the time of the accident showed normal shape of the acetabulum and femur; in a third the sequel was rarefaction of the femoral neck and subluxation of the head (Higgins). Elmslie and Rehbein both suggest that the changes in the femoral epiphysis are due to loss of the vascular supply that should accompany the ligamentum teres, of necessity ruptured by the accident. The condition, therefore, becomes interesting from the points of view of prognosis and of a suggestion as to a factor in the production of pseudocoxalgia. It seems worth while, for these reasons, to record a recent case and to make a short analysis of previously reported ones. It is my intention to follow up my patient systematically with a view to the discovery of sequelæ. The accompanying table contains every case in the literature that I have been able to find, fifty-three in all; it also includes my own recent case, and five others collected from the surgical case-books of University College Hospital.

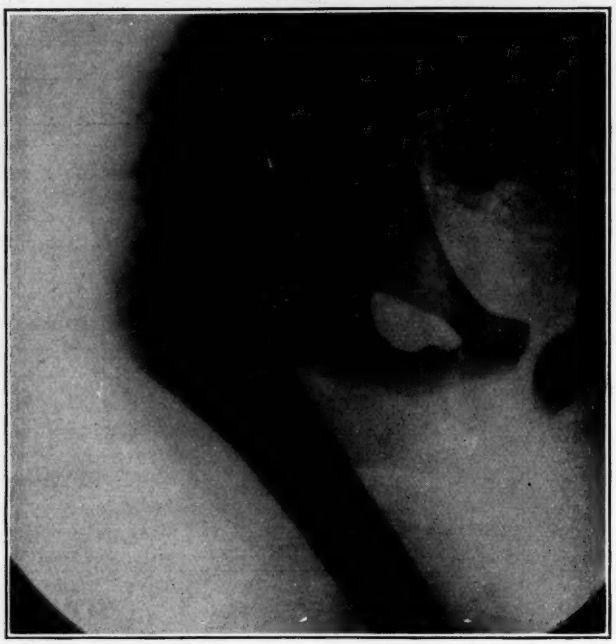

Fig. 37.—Traumatic dislocation of hip. Radiogram taken before reduction.

My own case is that of a boy (Harold B.), age 6 years, who during play endeavoured to carry on his back another boy, age 12. He was unable to bear the weight, his legs straddled, and the two boys fell, the elder and

heavier being on the top. A week later, on May 25, 1923, he was seen by Dr. Lightfoot, who diagnosed dislocation of the hip and sent the patient to hospital. He showed all the classical signs of a dorsal dislocation of the left hip; radiography confirmed the diagnosis and showed no signs of any concomitant fracture (*Fig.* 37). Reduction, under light anæsthesia, was readily accomplished by the usual manœuvres: traction, slow adduction, followed by outward circumduction and by rapid extension of the limb. An X-ray picture taken the next day showed that the head of the femur was in the acetabulum, and that there were no evidences of any damage to the epiphysis of the femoral head or any other abnormality. Movements of the hip, in bed, were free and painless. When I saw the boy six weeks later, the hip still appeared normal. He walked and ran without a limp, passive movements were free and painless in all directions, and a radiogram showed no abnormality. I have recently seen him again, on Jan. 10, 1924. He runs and walks freely without limp or pain. A radiogram (*Fig.* 38) shows no definite abnormality, though the outlines of acetabulum and femoral head are not quite so sharp-cut as in some pictures.

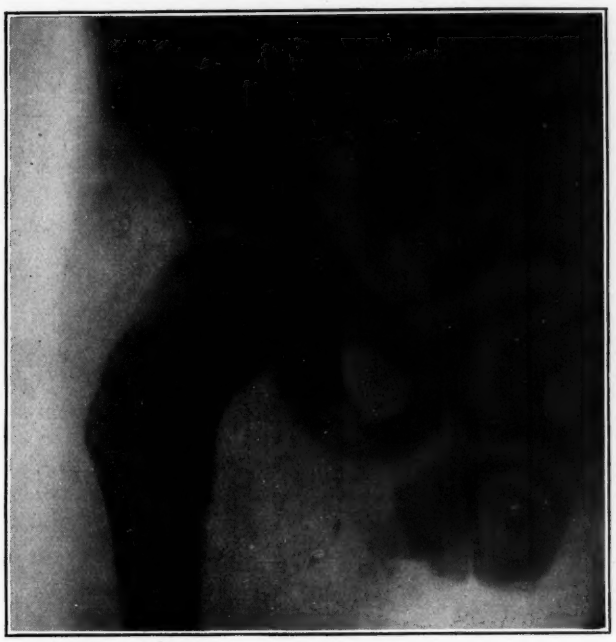

FIG. 38.—Traumatic dislocation of hip. Radiogram eight months after reduction.

Analysis of the reported cases reveals the following points:—

1. **Rarity.**—Only 59 cases are recorded. Maffei states that of 1842 hip luxations observed at the Rizzoli Institute of Bologna since 1901, there were only 3 traumatic dislocations in childhood.

2. **Sex.**—Males, 42; females, 16; not stated, 1.

3. **Age.**—From 11 months to 16 years (an old-standing case). Average about $7\frac{1}{2}$ years.

Ages	Cases	Ages	Cases
Between 0 and 3 ..	2	Between 11 and 13 ..	6
,, 3 and 5 ..	6	,, 13 and 15 ..	8
,, 5 and 7 ..	13	15 (an old-standing case)	1
,, 7 and 9 ..	12	Not stated ..	1
,, 9 and 11 ..	10		

4. **Side.**—Right, 22; left, 27; not stated, 10.

5. **Variety of Dislocation.**—Iliac (dorsal), 40; obturator, 7; sciatic, 6; suprapubic, 3; not stated, 3.

RECORDED CASES OF TRAUMATIC DISLOCATION OF THE HIP IN CHILDHOOD. Up to January, 1924.

No.	Name of Surgeon	Journal	Sex	Age. Years	Side	Type	Duration before Treated	Method of Reduction	Final Results and Notes
1	Bartels ..	*Arch. f. klin. Chir.* 1874, xvi	?	½	L.	Iliac	1 day	Manipulation	?
2	Bartels ..	Ditto ..	F.	14	R.	Iliac	?	Spontaneous reduction whilst being carried	?
3	Volkmann ..	*Deut. Zeits. f. Chir.* 1893, xxxvii	M.	13	L.	Iliac	13 weeks	Manipulation failed; femur broken	Hip ankylosis followed
4	Klee ..	*Brun's Beiträge z. klin. Chir.* 1889, iv	F.	8	R.	Iliac	3 days	Manipulation	?
5	Klee ..	Ditto ..	M.	14	L.	Sciatic	2½ months	Manipulation failed ..	?
6	Helferich ..	*Deut. med. Woch.* 1893, No. 32	M.	1½	L.	Iliac	24 hours	Manipulation	?
7	Helferich ..	Ditto ..	F.	4	L.	Iliac	14 days	Manipulation failed. Reduced by open operation	'Ideal'
8	Volkmann ..	*Deut. Zeits. f. Chir.* 1893, xxxvii	M.	9	R.	Iliac	7 weeks	Manipulation failed. Open operation: reduction	'Ideal' in 9 months
9	Drehmann ..	*Brun's Beiträge z. klin. Chir.* 1896, xvii	M.	7	R.	Iliac	3½ weeks	Manipulation after extension with weights	Good in a month
10	Drehmann ..	Ditto ..	M.	8	L.	Iliac	4 weeks	Manipulation only apparently succeded. Dislocation persistent after removal of plaster. Open operation. Epiphysis found separated. Refixed and reduction made	Walking with stick at end of 4 weeks
11	Endlich ..	*Arch. f. klin Chir.* 1898, lvi	M.	5	L.	Iliac	Old date	Open operation	Good 1 year, and still good 4 years after
12	Endlich ..	Ditto ..	M.	9	L.	Obturator	9 weeks	Open operation: reduction, but not stable. 2nd operation 2 months. Sequestrum formation in femoral head and necrosis of cartilage	3 years later: 'satisfactory'
13	Schoemann	Quoted by Doelle in *Arch. f. klin. Chir.* 1921, cxviii, 725	F.	7	L.	Obturator	?	Resection of hip	?
14	Cripps, Lawrence	Ditto ..	F.	4½	R.	Obturator	1½ months	Reduced by manipulation ..	?
15	Pietrzikowski	Ditto ..	F.	11	?	Obturator	3 months	Reduced by manipulation ..	?
16	Hirsch ..	Ditto ..	F.	4	L.	Iliac	14 days	Manipulation failed. Open operation 18 days later: reduction	Good 1 year later

15	Pietrzikowski	Ditto ..	F.	11	?	Obturator	3 months	Reduced by manipulation ..	?
16	Hirsch ..	Ditto ..	F.	4	L.	Iliac	14 days	Manipulation failed. Open operation 18 days later: reduction	Good 1 year later
17	Höfliger ..	Ditto ..	F.	5½	L.	Iliac with infratrochanteric fracture	4 months	Operative reduction. Suppuration	Walked in 4 weeks. Sequestrum & sinuses, fibrous ankylosis
18	Gerstner ..	Ditto ..	M.	8	?	Iliac	7 weeks	Operative reduction. Spontaneous redislocation 1½ months later. Second operation: remained reduced	?
19	Spenzer ..	Ditto ..	M.	7	R.	Iliac	—	Reduced but recurred. Operation 5 months later	Good. Could walk
20	Beil ..	Ditto ..	M.	13	?	Iliac	5 months	Operative reposition with subperiosteal separation of muscles from trochanter	Good
21	Jones, Sidney	Ditto ..	F.	11	?	Iliac	6 weeks	Manipulation failed. Operation: failure of reduction by open method. Resection of head	4 years later could run and walk
22	Tuchten ..	*Rev. de Chir.* 1902	F.	10	?	?	recent	Reduced by manipulation ..	Good (brother and sister)
23	Tuchten ..	Ditto ..	M.	8	?	?	recent	Ditto ..	
24	Hädke ..	*Deut. Zeits. f. Chir.* 1903, 66	M.	14	L.	Iliac	10 weeks	Reduced by open operation ..	7 weeks later movements were good
25	Seiderer ..	*Münch. med. Woch.* 1904, No. 32	M.	10	L.	Obturator	?	Reduced by Kocher's method of manipulation	Walked in 10 days
26	Peschties ..	*Inaug. Dissert.* Königsberg, 1908—quoted by Doelle	F.	6	?	Iliac	2 months	Open operation	?
27	Stressler ..	*Brun's Beiträge z. klin. Chir.* 1908, 58	M.	14	R.	Obturator	5 weeks	Manipulative attempts fractured upper third of femur. Fracture united. Then reduction by open method after 11 weeks	Legs equal in length & movements good
28	Bajardi ..	*Archivio di Ortopedia*, 1900, 17	F.	5	L.	Suprapubic	—	—	—
29	Dollinger ..	*Ergebn. d. Chir. und Orthop.* 1911, 3	M.	8	R.	Iliac	3 months	Manipulation failed. Open operation	3 years later, walking good and movements complete
30	Boehnke ..	*Arch. f. klin. Chir.* 1913, cii, 1077 (30 cases)	M.	5	L.	Iliac	3 months	Manipulation failed. Extension for 17 days. Manipulation again failed. Reduction by open operation	
31	Jalanguier ..	*Bull. et Mém. Soc. de Chir.*, Paris, 1904, 29	M.	10	L.	Iliac	?	?	?

RECORDED CASES OF TRAUMATIC DISLOCATION OF THE HIP IN CHILDHOOD—*continued.*

No.	Name of Surgeon	Journal	Sex	Age. Years	Side	Type	Duration before Treated	Method of Reduction	Final Results and Notes
32	Weil ..	Ref. *Zentralb. f. Orthop.* 1910 ..	M.	11	L.	Supra-pubic	?	Manipulation	Good
33	Weil ..	Ditto ..	M.	?	?	Iliac	?	Non-reduction of hip. Osteotomy to correct position	?
34	Rischbieth ..	*Lancet*, 1914, April 18	M.	10	?	?	?	Reduced by man pulation ..	Good. Walking in 28 days
35	Platt and von Mengershansen	*Lancet*, 1916, Jan. 8	M.	6	L.	Iliac	1 hour	Ditto ..	Walking in 1 month
36	Courtillet et Lombard	*Rev. Orthop.* 1911, v, 477	F.	3½	R.	Iliac	70 days	Ditto. Redislocation after 10 days. Reposition	Cure
37	Karenke ..	*Münch. med. Woch.* 1907	M.	13	L.	Sciatic	1½ hours	Reduced by manipulation ..	Good
38	Ritter (Doelle)	Ditto ..	M.	11	R.	Iliac	24 hours	Ditto ..	Ditto
39	Ritter (Doelle)	Ditto ..	M.	11	R.	Sciatic	2 hours	Ditto ..	Very good
40	Maffei ..	*Chir. d. Org. del Movimento*, 1922, vi, 619	M.	9½	R.	Supra-pubic	2½ years	Partial removal of femoral head and osteotomy of the femur	Ultimately satisfactory function
41	Maffei ..	Ditto ..	M.	13	R.	Iliac	5 months	Reduction by open operation ..	Good function after 1½ months
42	Maffei ..	Ditto ..	M.	6	L.	Iliac	48 hours	Reduction by manipulation ..	Perfect function after 2 months
43	Mouchet et Seguinot	*Rev. d'Orthop.* 1910	M.	16	L.	Iliac	11 years	Operation refused	
44	Mouchet et Seguinot	Ditto ..	M.	9	R.	Iliac	Recent	Reduction by manipulation at the second attempt	Good
45	Roederer ..	Quoted by Maffie	M.	10	L.	Iliac	6 years	Operation refused ..	—
46	Roello ..	*Chir. d. Org. del Movimento*, 1922, vi, 119	F.	5	R.	Sciatic	Several hours	Reduced by manipulation ..	Complete return of function
47	Roello ..	Ditto ..	M.	6	R.	Sciatic	A few hours	Ditto (Kocher's method) ..	Perfect function in 12 days
48	Roello ..	Ditto ..	F.	6	R.	Sciatic	4 days	Ditto ..	Ditto in 15 days

All the above cases are to be found in the lists of Boehnke, Boelle, or Maffei. In addition, I have been

48	Roello ..	Ditto ..	F.	6	R.	Sciatic	4 days	Ditto ..	Ditto in 15 days

All the above cases are to be found in the lists of Boehnke, Boelle, or Maffei. In addition, I have been able to find the following :—

49	Steinke ..	Quoted by Maffie	M.	10	R.	Iliac	Recent	Ditto	Good result
50	Rehbein ..	*Deut. Zeits. f. Chir.* 1922, clxxiv, 416	M.	8	R.	Iliac	A few hours	Easily reduced by manipulation. Radiograph showed normal-shaped head. Left hospital in 2½ weeks without any disability	1 year later was readmitted with the clinical and radiographic picture of Perthes' disease. (Rehbein suggests that it is due to injury of blood-vessels in ligamentum teres)
51	Murphy, D. P.	*Jour. Amer. Med. Assoc.* 1923, lxxx, 549	M.	8	L.	Iliac	A few hours	Easily reduced by manipulation under ether	?
52	Higgins, T. T.	*Proc. Roy. Soc. Med.* (Surg. Sect.), 1920–21, xiv, 62	M.	8	R.	Obturator	?	Aug., 1919 : Reduced by manipulation. Plaster case. Femoral head and neck normal as seen by X rays	In a few months developed limp. Nov., 1920 : Radiograph shows rarefaction of femoral neck ; epiphysis well formed. Some subluxation of head of femur upwards and backwards
53	Elmslie ..	*Jour. Orthop. Surg.* 1919, 1, 109	M.	4	L.	Iliac	8 days	Feb., 1914 : Reduced by manipulation. X ray then showed normal-shaped head, now in acetabulum again	Followed 1 year later by pseudo-coxalgia
54	Choyce, C. C.	Personal case ..	M.	6	L.	Iliac	7 days	May 25, 1923 : Reduced easily by Bigelow's manipulation under anæsthesia	Running and walking freely six weeks later ; radiogram then showed apparently normal hip. 8 months later (Jan., 1924) : No abnormality ; runs and walks freely

RECORDED CASES OF TRAUMATIC DISLOCATION OF THE HIP IN CHILDHOOD—*continued.*

No.	Name of Surgeon	Journal	Sex	Age. Years	Side	Type	Duration before Treated	History, and Method of Reduction	Final Results and Notes
55	Collected by C. C. Choyce	Surgical case notes, University College Hospital, London	M.	6	R.	Iliac	1 day	July, 1897. Climbing on a board, which fell with him. Reduced by manipulation	Left hospital in one week; walking well. No subsequent history — not traced
56	Ditto ..	Ditto ..	M.	8	L.	Iliac	1 day	Nov., 1898. Fell when carrying another boy on his back. Reduced by manipulation under chloroform	Went out of hospital in 4 days in Thomas's hip splint. Subsequent history not noted—not traced
57	Ditto ..	Ditto ..	F.	4	R.	Iliac	2 days	1889. Fell from sister's arms. Easily reduced by manipulation under ether	Double Thomas's hip splint. Subsequent history not noted — not traced
58	Ditto ..	Ditto ..	M.	6	?	Iliac	1 day	1888. Pushed over from behind by another boy. Reduced by manipulation under chloroform	Thomas's hip splint. Left hospital on 4th day. Subsequent history unknown
59	Ditto ..	Ditto ..	M.	11¾	L.	Iliac	1 day	1887. Tripped and fell with legs widely separated	Left hospital on 16th day—able to walk. Subsequent history unknown

6. **Method of Reduction.**—Manipulation, usually under anæsthesia, was successful in all cases in which it was tried within fourteen days from the date of the dislocation. In one of Helferich's cases (an iliac dislocation) it failed on the fourteenth day, and resort was had to open operation; the same was true of Hirsch's case. On the other hand, manipulation was successful as late as seventy days after dislocation in Courtillet and Lombard's case of iliac dislocation in a girl of $3\frac{1}{2}$; redislocation occurred ten days later, but reposition resulted in cure. The cases requiring operation ranged in duration from fourteen days to two and a half years; two later cases (six years and eleven years' duration) refused operation. Various operative measures were adopted: the most satisfactory route of access appears to have been by subperiosteal detachment of muscles from the great trochanter, or by detachment and subsequent fixation of the trochanter. In some cases operative clearance of the acetabulum and reposition of the femoral head was successful; in others resection of the femoral head was adopted.

7. **Results.**—Late results are seldom mentioned, especially in the earlier cases, the recorder being content to state the results as good, ideal, etc. In recently reported cases, however, several late sequels have been reported; it is reasonable, therefore, to believe that had the earlier cases been followed up the results would have been found to be less ideal than was supposed. Thus, in Elmslie's case limping began eleven months later and the condition progressed to one of pseudocoxalgia. Again, in Rehbein's case there were well-marked signs of pseudocoxalgia twelve months later. Both Elmslie and Rehbein suggest that the subsequent changes are due to tearing of the ligamentum teres and interference with the vessels running in it, which take a more important share in the nourishment of the femoral head in childhood than later, when the epiphyseal plate of cartilage between head and neck is less complete. In Higgins' case, too, late changes appeared in the head and neck; fifteen months after the accident there was limping, and a radiogram showed rarefaction of the femoral neck, and, although the epiphysis remained of good shape, there was some subluxation of the head of the femur upwards and backwards. It would appear advisable, therefore, to give a guarded prognosis as to ultimate changes; limping is apt to recur after a period of about a year, and pseudocoxalgia and similar changes may then be found.

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(The above contain references to 49 cases collected from the literature. I add the following 5 cases, making a total of 54 recorded up to January, 1924.)
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THE ETIOLOGY OF THE FEMORAL HERNIAL SAC.*

By J. PHILIP BUCKLEY, Manchester.

I am about to express opinions which I have been developing since 1911, and regarding which I have in succeeding years become more and more confident. My conclusions are based largely on clinical and operative observations. I purposely refrain from commencing the consideration of this subject by trying to show how it is that femoral hernia is more common in women than in men. It confessedly occurs quite commonly in males but more commonly in females. If we approach the subject by discussing why this is the case, there is a danger that our clear vision may be fogged when we come to consider, as I intend to do, why in a given case of femoral hernia, whether in a male or in a female, that hernia has developed.

In discussing the subject I must first briefly recall a few anatomical details of a simple kind; then I shall enumerate the various types of femoral hernia met with clinically; thirdly, I shall mention existing theories and attempt to disprove them; and finally my own views will be given. As an appendix, a few words will be added about the relative frequency in the sexes.

Anatomy.—Femoral hernia develops in the potential space between the femoral vein and the free edge of Gimbernat's ligament. On the inner side of this so-called crural ring is the resistant, sharp edge of Gimbernat's ligament; on the outer side is the collapsible femoral vein, whose collapsibility is somewhat masked in the normal unherniated subject by some fibrous tissue loosely attached on the one hand to Poupart's ligament, and on the other hand to the horizontal ramus of the pubis; anteriorly the ring is bounded by the resistant Poupart's ligament, and deeply by the horizontal ramus of the pubis covered by the pectineus muscle and fascia. On the abdominal side of the ring is properitoneal fat in direct continuity with what is known as the cribriform fascia, which is simply a tough fibro-fatty plug occupying the crural ring. The properitoneal fat, situated at the angle between the anterior abdominal wall and the brim of the true pelvis internally, and the wing of the ilium externally, is loose, easily stretched, and in some considerable quantity. Deep again to this fat is the peritoneum, itself loose and stretchable and having a definite adhesiveness to the properitoneal fat, so that when the one is pulled upon, the other is dragged with it. Superficially to the crural ring is the loose connective tissue of the thigh.

The Various Types of so-called Femoral Hernia met with Clinically.—I say 'so-called', because, accepting the definition of an abdominal hernia as a protrusion of an abdominal viscus through the parietes, we find that not all loosely called femoral herniæ do actually hold contents.

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* Paper read before the Manchester Surgical Society, April, 1923.

1. *Uncomplicated Herniæ.*—

a. A protrusion of properitoneal fat through the crural ring, expanding into the connective tissue of the thigh, covered by and definitely demarcated from the thigh fat by a smooth, thin, delicate fascia. It forms a soft, defined, subcutaneous mass in the upper part of the thigh, easily felt on palpation but not very obvious on mere inspection, and containing no peritoneal sac.

b. Commoner than the first type, but resembling it clinically in every way, and only differing from it in that it is usually larger, and that in the midst of the fatty mass is a definite but empty peritoneal sac in direct continuity with the general peritoneal cavity by means of a very narrow neck, through which it is difficult to squeeze even the first joint of the little finger, but which is easily and permanently stretched by inserting the closed blades of a pair of Spencer Wells' forceps and opening them. This feature explains why mention has been made of the presence of some fibrous tissue on the outer side of the neck of the sac, which masks the collapsibility of the femoral vein.

c. A similar type of peritoneal sac covered by a thick layer of properitoneal fat, but containing omentum. This, in my experience, is the commonest type. In virtue of its contents it is larger and more conspicuous than the second type, and its neck is wider, being stretched by the omentum passing through it.

d. The sac is larger, and its properitoneal covering is thinned by the expansion of the sac secondary to the increase in the amount of the contents. It usually contains omentum only, but in an old hernia in which the neck has been very widely stretched bowel may, but in my experience uncommonly, occupy the sac without being strangled.

Here I feel I must call attention to a statement in a well-known textbook on surgery,[1] because it is so contrary to my own experience. It says: " Femoral herniæ are less liable to contain omentum than the inguinal variety; a portion of the ileum is most often present ". It may be acknowledged that in cases which are operated on for strangulation the strangulated viscus is almost always the ileum; but surely the contents of an uncomplicated femoral hernia are in the large majority of cases omentum.

2. *Complicated Herniæ.*—

a. Strangulation of properitoneal fat in the variety where there is a fatty sac without contents. I have seen one case of this type where suddenly the properitoneal fat with its contained sac was forced down, with the formation of a tense swelling, which was tender to the touch, but was accompanied by no vomiting and practically no shock. On exposure, the fatty sac had a faint mottled purple colour due to the passive hyperæmia. This case was admitted to the Manchester Royal Infirmary as an 'urgency'.

b The type where omental contents have become strangled.

c. The type where a knuckle of bowel has been forced through the narrow neck of the sac and become strangulated. Sometimes only a portion of the lumen of the bowel is involved, producing the partial enterocele of Richter. Usually in neither of these forms does the bowel occupy the whole sac, and this fact, of course, strongly supports the theory of a pre-formed sac.

THEORIES OF SAC FORMATION.

Having mentioned the various types of femoral hernia, which later will be seen to be of importance in the development of my theory, I shall now proceed to state and briefly criticize the existing theories. These, as far as I am aware, are two in number: (1) That which Murray[2] refers to as the 'orthodox teaching'; and (2) That of Hamilton Russell,[3] which he calls the 'saccular theory'. The latter theory was strongly supported by Murray.

1. **The Orthodox Theory.**—The so-called orthodox theory holds that the sac of a femoral hernia develops contemporaneously with the extrusion of the viscus. Thus, to quote from Gray's *Anatomy*:[4] "When a portion of intestine is forced through the femoral ring it carries with it a pouch of peritoneum, which forms the hernial sac".

Now I maintain, and I think the supporters of Russell's 'saccular theory' do so too, that this theory is quite put out of court by the fact that we frequently meet with those cases mentioned above of an empty sac, richly covered with properitoneal fat and having a very narrow neck. When we meet with such cases at operation it is to my mind obvious that they have never held any contents, because, firstly, if the contents had been passive omentum, that omentum would have been held so tightly at the neck that it would never have been possible for it to have returned into the abdomen and it would soon have acquired adhesions at the neck, a condition which is almost always found to exist when omentum is present in the sac; secondly, if the contents had been bowel, that bowel must have been strangulated by the narrow neck, which condition would have manifested itself by symptoms of strangulation and obstruction. Again, when we come across cases of strangulated gut in a femoral sac, that gut is almost always smaller than the sac itself, and this alone strongly suggests that the sac has been a pre-existing one

2. **The Saccular Theory.**—Hamilton Russell defines his theory thus:[5] "The theory rejects the view that hernia can ever be 'acquired' in the pathological sense, and maintains that the presence of a developmental peritoneal diverticulum or sac is a necessary antecedent condition in every case of ordinary abdominal hernia".

Murray explains this theory, as applied to femoral hernia, fully and with care in his book *Hernia, its Cause and Treatment.* In criticizing the theory, I propose to follow his line of thought as expressed in this book. He says:[6] "It is then surely reasonable to believe that a crural gubernacular attachment, developed in excess of the normal, may, without producing an abnormal descent of the testicle, drag upon the peritoneum sufficiently to make a dimple in the crural region, which, with the growth of the individual, will develop into a potential hernia sac". As I understand it, this means that the crural attachment of the gubernaculum, excessively developed, arches round the external pillar of the external ring of the inguinal canal, reaches the groin, and, burrowing up between the femoral vein and Gimbernat's ligament, attaches itself to the peritoneum, and by muscular or cicatricial contraction drags down that peritoneum to form the sac of a potential femoral hernia.

Murray supports Russell's theory as follows. He mentions a case, described

by Macready in his *Treatise on Ruptures*, where three femoral sacs were present,[7] " one in the usual position of a femoral hernia, a second peritoneal sac had traversed Gimbernat's ligament, and a third protruded over and to the outer side of the femoral artery ". Murray says,[8] " the fact that three diverticula were found in close proximity is in favour of the developmental view ", and adds,[9] " that view receives support from their shape, for it is distinctly stated that the abdominal entrance of both these pouches was narrower than the fundus. Had these diverticula been produced by the bowel pushing the peritoneum in front of it, then the mouth of each sac would have been wide ". The first of these reasons seems to give no valuable support to the theory. The second statement is true, but does not seem exclusively to support the congenital theory. It seems only to exclude the 'orthodox' theory.

Murray notes[10] that Macready, referring to persons seen at the City of London Truss Society during 1888, 1889, and 1890, records 22 cases of femoral hernia in males under 15 years of age, and 42 in females; but he does not mention that these were taken from a total of 461 males on the one hand, and of 1197 females on the other; nor does he tell us that among the males not one of the cases occurred in the period of 1 to 5 years, and among the females none occurred under 1 year and only five under 5 years; whereas in a condition acknowledged by all to be of congenital origin, viz., inguinal hernia, in males more than a sixth and in females nearly a seventeenth occurred before the age of one year, according to statistics taken from the London Truss Society's Clinic. Surely, if the sac of a femoral hernia were a congenital one, we should expect that those children who became actually ruptured during the first fifteen years of life would be much commoner than one twenty-sixth of all cases. For the same period—viz., the first fifteen years of life—in cases of inguinal hernia the proportion is midway between one-third and one-fourth. Apparently in this connection the proportion would be higher if direct and therefore acquired inguinal herniæ had not been included in the statistics of the Clinic; I presume that they were so included in the absence of any statement by Macready to the contrary.

Further, Murray says[11] that in 200 consecutive post-mortem examinations, femoral diverticula were found in 47 bodies.

According to the theory which I shall later expound, this is not a very surprising thing quite apart from a congenital explanation. Also it would seem extraordinary, assuming Russell's theory to be correct, that in 23 per cent of cases what must be described as a developmental abnormality should have occurred. Keith, I believe, points out that no one has seen a diverticulum within the femoral canal at birth. Murray does indeed mention that in Ashby and Wright's *Diseases of Children* it is stated that Sabourin recorded a case of femoral hernia in a premature infant.

Finally Murray says[12] that " if the sac of a femoral hernia is formed originally in this way " (viz., " by some force pulling, rather than pushing, the peritoneum outwards "), " then some atrophied gubernacular fibres should be found at the fundus of the sac ". He writes, " a few weeks after I had written the above remarks I secured in the post-mortem room the sac of a femoral hernia from the body of a man 61 years of age ". This he sent to

the Clinical Research Association in London for microscopical examination. He received the following report : " Sections made longitudinally of the fundus of this hernial sac certainly show small bundles of striated muscle ". Murray does, however, confess in a footnote that " recently I sent two femoral hernial sacs to the Clinical Research Association for examination, but the presence of muscle fibre at the fundus of the sac could not be demonstrated ". Again he says, " I have not yet had the opportunity of searching for muscular fibres at the fundus of a femoral hernia sac in a woman, but I feel confident of finding them there ".

Embryologists in general definitely and dogmatically assert that the muscle fibres of the gubernaculum are non-striated. But quite apart from this question as to whether these fibres are striated or not, who would expect that in a sac alleged to be 61 years old fibres of muscle would still remain in a condition to be defined—a very delicate muscle at its best, and one which had not been called upon to contract for 61 years ! Murray clears up the question of striation or non-striation of the gubernacular fibres to his own satisfaction by demonstrating striated muscle fibres from " behind and below the epididymis of an adult ".[12] He briefly says, " it represents normal gubernacular fibres in the mesorchium ". One wonders, however, if these are not more likely to be fibres of the cremaster muscle.

I have spent some space in questioning the correctness of Russell's theory as applied to the femoral sac, more especially because in perusing recently a paper by Panton,[13] " Factors bearing upon the Etiology of Femoral Hernia ", to which I shall have occasion to refer later, I note that he accepts Russell's theory of the formation of the femoral sac, and accepts it, I think, too readily. One point especially appears to throw doubt on the congenital saccular theory which has as its basis the excessive growth of the gubernaculum ; that point is the fact that although femoral hernia is more common in the female, yet in the female the gubernaculum is a much less active structure, if physiological results are anything to go by.

3. **The Author's Theory.**—My theory will not take long to enunciate. It is very simple and easy to understand. It may be called the 'acquired saccular theory', in contradistinction to the 'saccular theory' of Hamilton Russell, in which the sac is regarded as congenital or embryonic.

Man has an acknowledged weakness in the abdominal parietes at the crural ring. On the abdominal side of the ring we have an accumulation of loose properitoneal fat, which on its deep aspect has a certain adhesiveness to the peritoneum, which in its turn is loose and easily stretched. On its superficial aspect this fat is in direct continuity with the fat which plugs the space known as the crural ring. I have formed the opinion that under the influence of intra-abdominal pressure the properitoneal fat is herniated under Poupart's ligament between the femoral vein and Gimbernat's ligament into the thigh, carrying with it a small peritoneal diverticulum. Having once passed the narrow neck, it is allowed to expand into the connective tissue of the thigh, which is less resistant than the tissues around the neck of the sac. This expansion after passing the neck prevents its easy return through the crural ring. Occasionally the hernia of the properitoneal fat fails to bring down a peritoneal diverticulum, and we then get the type which I have

mentioned as the protrusion of properitoneal fat not containing a sac. It would appear to me that this hernia of properitoneal fat usually occurs gradually as the result of everyday abdominal strains, and up to a certain point may gradually increase in size simply in virtue of fresh abdominal fat being forced down. Surgeons will no doubt have noticed how, when one of these fatty sacs is exposed, a pull on it will bring down more fat from the deep side of the crural ring.

This gradual development seems to explain how it is that the small fatty sac may remain undiscovered until it acquires contents. On the other hand, more rarely it may occur suddenly, as in the case mentioned above, where there was a sudden strangulation of properitoneal fat containing a peritoneal sac. The fatty sac lies in the tissues of the thigh as an inconspicuous flat swelling, smooth and soft, but quite typical, and easily recognized by palpation. As a rule it causes no pain or discomfort, and even the subject may be unaware of its presence until it acquires some contents.

The sac within the properitoneal fat is often small and not easily found by the uninitiated when for the first time he is called upon to operate on such a case. In fact the novice will often jump to the conclusion that the thin fascia which demarcates this properitoneal fat from the fat of the thigh is the peritoneal sac itself.

The sac will remain of moderate size until at last some omentum finds its way in. Once in, the omentum, I maintain, can never get out again, being a passive structure held in the tight grip of the neck. More and more omentum comes down into the sac, so that the neck and the sac become more and more distended. As the sac becomes distended its fatty covering becomes more and more thinned, until in a well-developed hernia the peritoneum may have only a very thin layer of fat covering it. Quite a different picture is then presented from that of the small empty fat-laden sac of the early stage.

It is interesting to note that hernia of properitoneal fat is accepted by many as the cause of the fatty ventral herniæ found on one or other side of the linea alba, usually above the umbilicus. To quote from Thomson and Miles' *Manual of Surgery*[14] in this connection: "A lobule of fat may be protruded through one of the spaces of the network. . . . As the plug of fat is further protruded it drags behind it a funnel-shaped process of peritoneum, which ultimately becomes the sac of a hernia". How much more likely is this to occur at the very dependent site of acknowledged abdominal weakness, the crural ring. It must, however, be admitted that Murray states[15] that these herniæ in the linea alba are of congenital origin, though not, of course, due to errant gubernacula.

Relative Frequency of Femoral Hernia in Males and Females.—If the active cause of both the original protrusion of the properitoneal fat with its peritoneal sac through the crural ring, and the passage of viscera later into the sac, is intra-abdominal pressure, it is evident that any condition which chronically increases the intra-abdominal pressure renders a person of any age or sex more likely to develop a hernia of properitoneal fat, or to acquire by the protrusion of viscera an actual in place of a potential hernia.

I think we may take it for granted that the shorter Gimbernat's ligament is, the broader will be the space between its free edge and the femoral vein, and therefore the more likely is the individual to develop a femoral hernia, potential or actual. But in view of Panton's work we must be careful not to make use of the size of Gimbernat's ligament in order to find a reason why the female is more liable to the development of a femoral hernia than the male. In relation to the relative sizes of Gimbernat's ligament in the two sexes, he says,[16] " the female average exceeds the male on the right side by 1 mm. only, and the left side measurements are in perfect agreement ". He concludes, therefore, " that the sexual differences in the length of Gimbernat's ligament are negligible ". Another point which he brings out is[17] that the " female false pelvis is either relatively narrower than the male, or else equal to it; it certainly is not greater ". He also says, " the female Poupart's ligament is relatively shorter than the male ". His actual figures are : modern male average (Poupart), 12 cm. ; female, 11·8 cm. As the greater frequency of femoral hernia in the female has in the past been accounted for practically universally on the grounds that the female false pelvis is wider than the male, we must, in view of the results of Panton's painstaking research, readjust our ideas on the subject.

I have been studying some statistics prepared by Macready from the Clinic of the City of London Truss Society during the years 1888, 1889, and 1890, contained in his inspiring work[18] *A Treatise on Ruptures.* He calculates that between the ages of 21 and 65, the ages signifying when the rupture first appeared, the proportion of parous to non-parous women is as 3 to 1. Between these two ages we find in his complete tables 1037 women and 396 men suffering from femoral hernia. If to the female cases we apply the 3 to 1 proportion, we obtain roughly 778 parous women and 259 non-parous women. Therefore during the above three years we find the males have a majority of 137 over non-parous women. Of course we have to take another point into consideration—viz., how many of the parous women would have become ruptured even if they had not borne children. It is not easy to see how we can obtain this figure, but let us suppose it to be 20 per cent. This would mean that of the 778 parous women, 155 would have become the subjects of femoral hernia even if they had not had any children. Adding the 259 cases in non-parous women, we arrive at a total of 414, a majority of 18 over the men.

This juggling with figures may not be worth much, but I think that, coupled with Panton's findings, it is strongly suggestive of the idea that men are almost as liable to femoral hernia as women before they have had children, and therefore, that child-bearing is the one great factor which renders the female sex more liable to femoral hernia than the male. This is not surprising when one considers that for ten lunar months the intra-abdominal pressure is gradually increasing in a pregnant woman, and that this period is terminated by a still greater and more violent increase of pressure in the final act of expelling the child. It is true that for some part of the ten months the omentum and gut is kept away from the crural ring by the enlarged uterus ; but what better conditions could be looked for than these for the pushing of properitoneal fat with the small peritoneal sac through the crural ring into

the thigh ? One point, however, as far as I know, remains unexplained by any theory, and that is that among the comparatively few cases of femoral herniæ which occur before the age of puberty, about two-thirds occur in the female sex.

In 1911 I devised a method of treating the sac in the radical cure of femoral hernia, in which the sac was invaginated through the abdominal cavity and out through the anterior abdominal parietes well above Poupart's ligament. Here the sac was ligatured, cut off, and fixed. By this means the peritoneum and the properitoneal fat were drawn well up and away from the abdominal aspect of the crural ring. Having satisfied myself of the efficacy of this method by a three years' trial, I published it in 1914.[19] With a few slight modifications in technique, and with the assistance of a special invagination forceps made for me by Thackray, of Leeds, I still use this method entirely in cases of both simple and strangulated femoral herniæ. I devised this method when I was beginning to realize the possible bearing of the properitoneal fat in the region of the crural ring on the development of the femoral hernial sac, and also the influence which this fat might have in producing a recurrence of the condition.

CONCLUSIONS.

1. That the sac of a femoral hernia is a pre-formed sac, and is not formed contemporaneously with the expulsion of a viscus.
2. That there is no sufficient proof that this pre-formed sac is of congenital or embryonic origin.
3. That the sac is acquired as a result of properitoneal fat being herniated into the thigh through that naturally weak site in man, the crural ring, and that this hernia of properitoneal fat drags with it a small peritoneal sac.
4. That anatomically a man is as much liable to a femoral hernia as a woman, and that the greater frequency of the condition in women is due to pregnancy and to the prolonged period of raised intra-abdominal pressure which that condition produces.
5. That no existing theory as to the etiology of femoral hernia accounts for the fact that among the comparatively few cases which occur below the age of 15 years, females have a two to one majority ; but that this fact serves to throw doubt on the embryonic theory, in that normal physiological results suggest that the gubernaculum is a more active structure in the male than in the female.

Since writing this paper, I have been interested to see Mr. Russell's[20] short article in the BRITISH JOURNAL OF SURGERY, " Femoral Hernia, and the Saccular Theory ". When he says, " During these years (1906 to 1923) I believe I may safely say that the saccular theory 'prevailed' and became firmly established among surgeons and surgical writers ", I must confess that I am surprised and I think he is too optimistic in making the statement.

I note that he makes a strong point in reference to the direction taken " by a femoral hernia of any size after its emergence from the saphenous

opening ", and he objects to the explanation often offered that the hernia follows the path of least resistance. He says, " the explanation becomes at once simple and obvious as soon as we recognize that the sac is a congenital structure ". I fail to follow his reasoning, because it would seem to be obvious that in looking for the direction of the forces acting in bringing down the sac in the first instance, we must study the sac before it has changed its primary direction, as it does change it when it reaches the area of weakness in the deep fascia known as the saphenous opening. Now in my experience the direction taken by the sac before it has reached the saphenous opening is always downwards alongside the femoral vein, and therefore it would seem that without doubt the primary producing force, whether acting from above or below, must have been downwards. If the force had been produced, as Murray says, by the crural attachment of the gubernaculum, then one would have expected that the direction of the young sac would have been upwards and slightly inwards, namely, towards the point of exit of that strand of gubernaculum from the inguinal canal.

In reference to Panton's paper, Russell says that Panton has " clearly demonstrated the congenital origin of the femoral sac ". I have read Panton's paper carefully, and I think that the above statement by Russell is too strong. What Panton has done is to make us readjust our ideas regarding the cause of the greater frequency of femoral hernia in women than in men, and realize that that cause is not a wider false pelvis, a longer Poupart's ligament, or a shorter Gimbernat's ligament. Regarding the question of whether there is a congenital factor in the etiology, he seems merely to review the existing evidence, especially as put forward by Murray, and to base his opinion on that without producing any additional evidence in support of the congenital theory. He certainly accepts the congenital theory, but, as I have said, I think that he does so too readily.

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THORACOSCOPY IN SURGERY OF THE CHEST.

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Following the first use of the thoracoscope by Jacobæus some twelve years ago, thoracoscopy has become increasingly practised in the different European countries, and more especially in Scandinavia. It was primarily used as a method of diagnosis of the causative factors giving rise to exudative pleurisy, and only later developed into a means of treatment of pleural adhesions preventing pulmonary collapse in the treatment of pulmonary tuberculosis by artificial pneumothorax. This method of diagnosis and treatment has not, as yet, obtained much prominence in this country, and it is with a view to increasing its employment that this preliminary report is published.

The Thoracoscope.—Before proceeding to discuss the technique, it is advisable to give a brief description of the instrument.

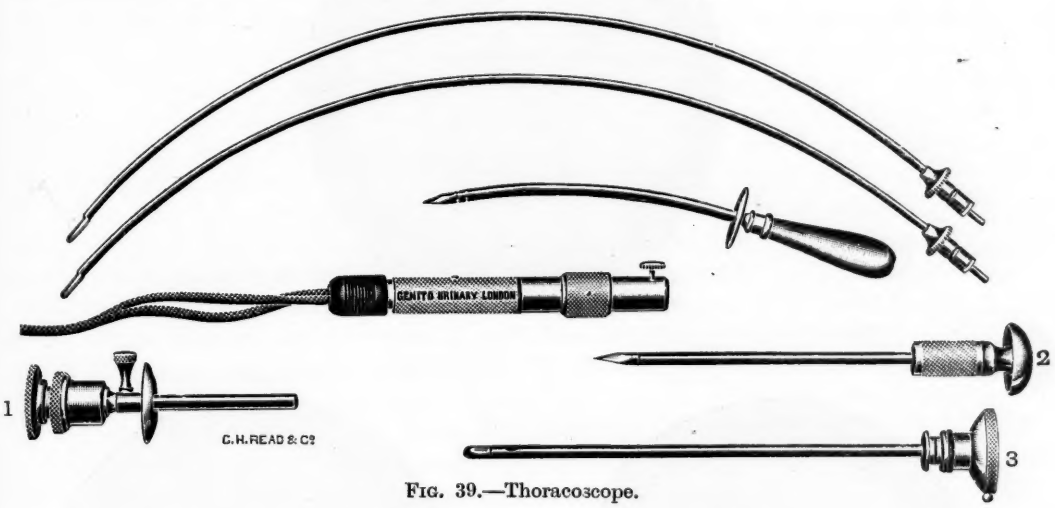

Fig. 39.—Thoracoscope.

The thoracoscope (*Fig.* 39) consists of a valved cannula (1), on the distal portion of which can be seen a shield, which, by adjustment of a small screw, can be varied in position; (2) is a simple trocar and cannula, the latter being to protect the point of the trocar in its passage through the valved cannula; (3) represents the telescope and terminal light, which also fits accurately the valved cannula. The remaining figures consist of the further instruments necessary for the cauterization of adhesions, and include two electric cauteries, the trocar and cannula for their introduction, and the connection and switch.

Technique.—

Preliminary.—The operation of thoracoscopy depends for its performance upon the presence of a space between the parietal and visceral pleuræ, and

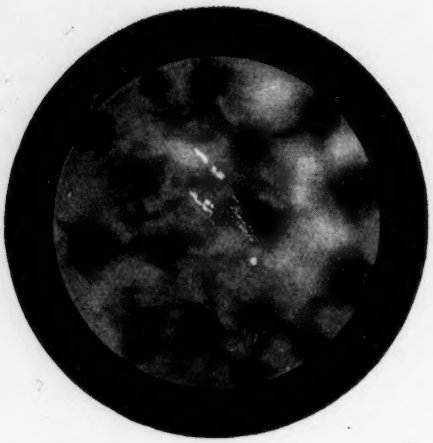

FIG. 40.—Normal lung (near view).

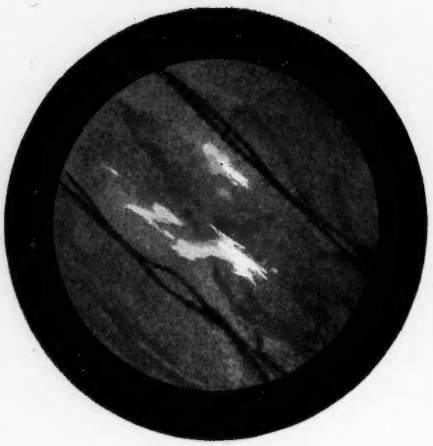

FIG. 41.—Normal pleura (near view).

FIG. 42.—Outer edge of lung, with inner surfaces of ribs and intercostal spaces in lower left segment.

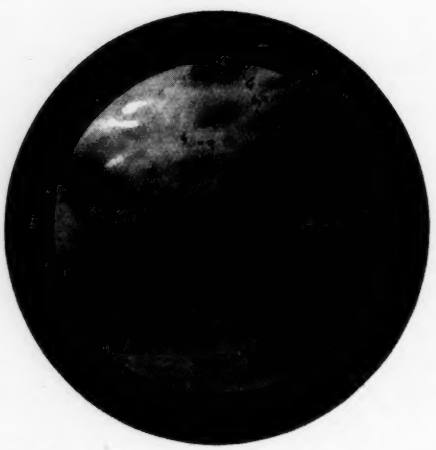

FIG. 43.—Lower edge of lung, showing diaphragm to right and parietes below.

FIG. 44.—Outer inferior angle of lung above, diaphragm to right, and parietes below to left.

therefore, in those cases in which artificial pneumothorax has not already been induced as a method of treatment, its induction forms a necessary preliminary.

Where an effusion is present, the fluid is drawn off and replaced by gas.

The artificial pneumothorax can be induced by the introduction of oxygen, nitrogen, or air. The most common, from the point of view of treatment, is the introduction of air, previously filtered, but in cases where the induction is carried out solely for diagnosis or investigation it is advisable to use oxygen. In my opinion, there are two reasons for this: first, that, should it be necessary subsequently to perform thoracotomy, less difficulty will be found in obtaining rapid expansion of the lung, owing to the increased rate of absorption of oxygen in the meantime; secondly, the risk of gas embolism, at the first induction, is eliminated. Several inductions of gas will generally be required before the pleural separation is enough to give a comprehensive view.

Following the pneumothorax, skiagrams of the chest should be taken, preferably stereoscopic, in order to disclose any large areas of pulmonary adhesions and to indicate the most favourable site for the operation.

Operation.—This is preceded by an injection of omnopon, or of morphia, atropine, and hyoscine, and the skin of the chest wall prepared as for any surgical procedure.

The position of the patient upon the operating table is of some practical importance, as the facility of the operation is thereby increased. The patient is placed on his side, that side to be examined being uppermost, and a sandbag is arranged high under the lower axilla, and a pillow under the head. In this way the convexity of the spine towards the affected side is increased and the intercostal spaces are thereby widened.

The site of introduction of the thoracoscope will vary according to circumstances, but will necessarily depend upon two factors: (1) That it is necessary to introduce the instrument as near as possible to the area to be examined; and (2) That it is essential to be quite sure that it is not introduced into adherent lung. Both these points can be controlled by careful examination of the preliminary skiagrams. In general, the line just internal to the vertebral border of the scapula, after its rotation outwards by elevation of the arm, will be found suitable.

Having selected the site, the skin, subcutaneous tissues, and deep structures are freely infiltrated with novocain and adrenalin ($\frac{1}{2}$ to 1 per cent). It is important, if the operation is to be carried out painlessly, that great care be taken to infiltrate down to and include the parietal pleura. The latter can be ensured in every case by steadily infiltrating as the needle is being thrust inwards until, on withdrawing the piston, gas comes freely into the barrel.

A small incision large enough to admit the trocar is made in the skin with a tenotome, the shield on the cannula is adjusted to the thickness of the chest wall, and the trocar and double cannula are thrust steadily through the intercostal space, into the pleural cavity. The trocar is then withdrawn and replaced by the telescope, and the cavity illuminated. The cannula is held with the shield firmly pressed against the chest wall, and the telescope now moves freely inwards and outwards. By movement of the instrument

FIG. 45.—View of normal appearance of inner surface of chest wall, ribs, and intercostal spaces.

FIG. 46.—Distant view of outer edge of lung and chest wall.

FIG. 47.—Similar view to that in *Fig.* 46, but somewhat closer.

FIG. 48.—Site of needle punctures from gas refills: they appear as small vesicles.

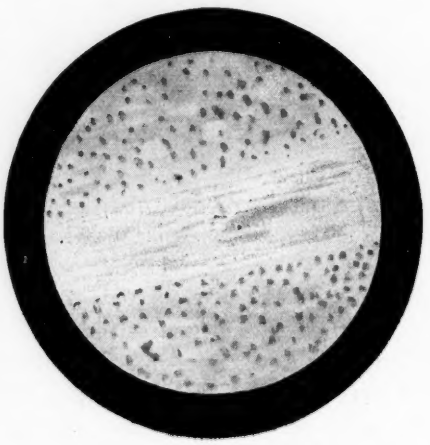

FIG. 49.—Fibrous scar on surface of parietal pleura (? site of previous adhesion).

as a whole, lateral movement is obtained in addition, and by a combination of these movements the entire pleural cavity can be examined.

The Normal Pleural Cavity.—In the first place, it is important to remember that in all endoscopic vision the area under observation depends for its appearance on the distance of the prism of the telescope from the object and on the brightness of the illumination. Bearing this point in mind, it will naturally follow that the variation in appearances of structures in the large pleural cavity will be considerable—much greater than those of smaller cavities such as the bladder.

Fig. 40 shows the characteristic appearances of the normal lung when a 'close-up' view is obtained. It will be seen to be of a pale-salmon colour, with irregular areas of dark pigmentation, varying from grey to black, scattered irregularly. Small vessels can be seen in or below the visceral pleura, and the whole surface glistens owing to the thin film of moisture covering it. As a whole the appearance closely resembles a highly-polished marble. Various portions of the lung can be recognized, and *Figs.* 42, 43, and 44 show the outer edge, lower edge, and lower outer angle respectively.

On turning the telescope towards the parietes a close view of the pleura will appear, as in *Fig.* 41, where the surface is of a much brighter pink colour and distinct blood-vessels can be seen. The white patches represent the reflection of the lamp from the moist surface. A more distant view can be seen in *Figs.* 45, 46, and 47, where the inner surfaces of the ribs and intercostal spaces can be clearly defined.

Turning downwards, the view is as represented in *Figs.* 43 and 44, where the darkened area of the left lower portion represents the parietes somewhat poorly illuminated, with the diaphragm bulging up in the lower right portion. The division between these two structures is the phrenico-costal sinus, in which it is not uncommon to find a small quantity of fluid.

Owing to the crowding of the lung about the hilum by the gas displacement, it is not possible to see structures in this situation unless they project considerably beyond the normal lung.

Pathological Conditions in the Pleural Cavity.—The most common pathological conditions arising in the pleural cavity occur as a result of tuberculosis.

The first is due to actual involvement of the pleura itself by the disease. I have not had this condition drawn, but it is quite a typical picture. Both layers of the pleura are considerably congested; the areas of pigmentation are hidden by a fine layer of granulation tissue, scattered through which small typical greyish nodules can be seen.

The second variety consists in the formation of adhesions between the two layers of pleura, not uncommonly overlying the site of a tuberculous cavity in the lung. These adhesions can be divided for practical purposes into three main groups: (1) Large flat surface adhesions extending over a comparatively large area of lung surface and appearing through the endoscope as a fusion of the two layers. These are most common at the apex. (2) Thin film-like adhesions, which are comparatively narrow when viewed from one aspect, but much broader from the other. This type can be seen oscillating during the examination, often synchronous with the heart-beat. They are well illustrated by *Figs.* 50 and 51, showing the same band from two directions

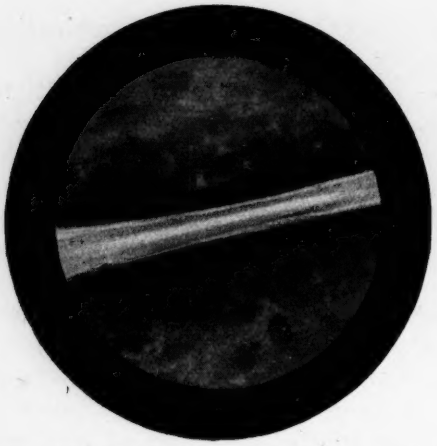

FIG. 50.—Membrane-like adhesion stretching across field ; attachments out of line of vision.

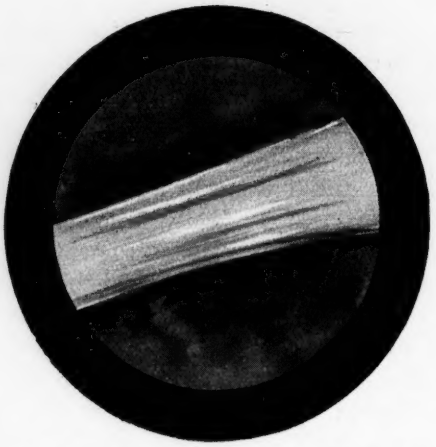

FIG. 51.—Same band as in *Fig.* 50, but from another view at right angles to the former.

FIG. 52.—Complete view of short band towards apex, with edge of another band at lower left corner.

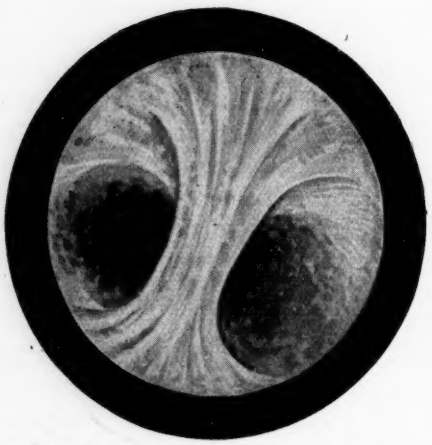

FIG. 53.—Firm band-like adhesions, showing pulmonary and pleural attachments.

FIG. 54.—Pulmonary end of strap-like adhesion, with small mass of granulation tissue on lung above attachment, and parietes in distance.

at right angles to one another. (3) Longer or shorter strap-like adhesions, firm, pale, and fibrous-looking. These are almost invariably spread out at each end, with a slighter narrower waist towards the middle. They appear, and are, much more firm than the former variety, and show little or no movement. They are well represented in *Figs.* 52, 53, 54, and in the last is a small quantity of granulation tissue, probably representing the site of rupture of another adjacent band by the introduction of gas. *Figs.* 48 and 49 are of some interest, the former representing the site of needle punctures which had been made to produce the artificial pneumothorax, the point of entry being now small cysts; and the latter a small area of scar tissue on the parietal pleura, possibly the site of a previously ruptured adhesion.

Indications and Contra-indications.—The method is indicated for diagnosis in all cases in which there is any real doubt as to the condition present in the pleura; for tumours growing from the pleura itself or projecting into the pleural cavity; and for the division of adhesions preventing collapse of the lung during the treatment of tuberculosis by artificial pneumothorax. This treatment is not considered in this communication.

The contra-indications consist of inability to induce a fairly considerable pneumothorax, and the presence of acute septic infection of the pleura. If performed for tuberculous empyema, great care must be taken, and the instrument should be introduced into the upper part of the pneumothorax cavity in order to prevent the subsequent formation of a fistula.

Complications.—The only complication, if such it may be called, that I have encountered, is the occurrence of a slight degree of surgical emphysema around the site of entry. The formation of a small quantity of fluid is quite common after induction of pneumothorax alone, and the frequency does not appear to be increased after thoracoscopy unless actual division of bands by the cautery is undertaken.

In conclusion, I should like to thank my medical colleagues at the Brompton Hospital for the opportunity of carrying out these investigations, and to express my indebtedness to Dr. P. L. T. Bennett, late Assistant Resident Officer, for his very excellent reproduction of the majority of the coloured drawings shown.

TWO RARE BONE DISEASES: HEREDITARY DEFORMING CHONDRODYSPLASIA AND CHONDRODYSTROPHIA FŒTALIS.

By J. RENFREW WHITE, Dunedin, New Zealand.

The three cases recorded and illustrated in this note have come under the writer's care within the last year. They have been considered worthy of record, partly because of the comparative rarity of the two diseases of which they are typical examples, but also because of the remarkable similarity of the clinical appearances presented in *Cases* 1 and 3 by two diseases of bone growth the essential natures of which have been regarded as almost diametrically opposite.

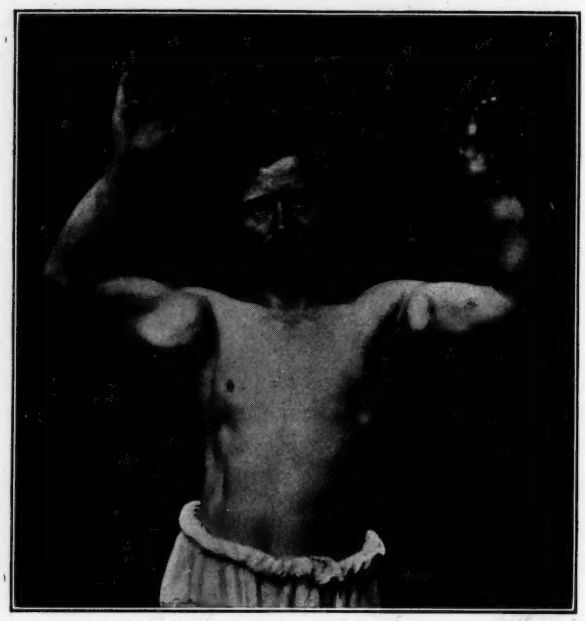

Fig. 55.—*Case* 1. Deforming chondrodysplasia. Note the symmetrical outgrowths from the metaphysial parts of the humerus, and the lower ends of the radius and ulna; the deformity of the forearms, and the outgrowths from the ribs.

Case 1.—**A case of deforming chondrodysplasia (multiple cartilaginous exostoses or diaphysial aplasia).**

G. M., age 26, a farm labourer, was admitted to hospital on May 13, 1923, complaining of: (1) Multiple swellings in the neighbourhood of the joints of the limbs that have been present since childhood; (2) Limitation of the range of movement at the shoulders and in the forearms, noticed for the last few years; (3) Pain on movement of the shoulders, of a few weeks' duration.

History.—The swellings were first noticed when the patient was a child, but exactly at what age he cannot now say; they have been growing slowly ever since.

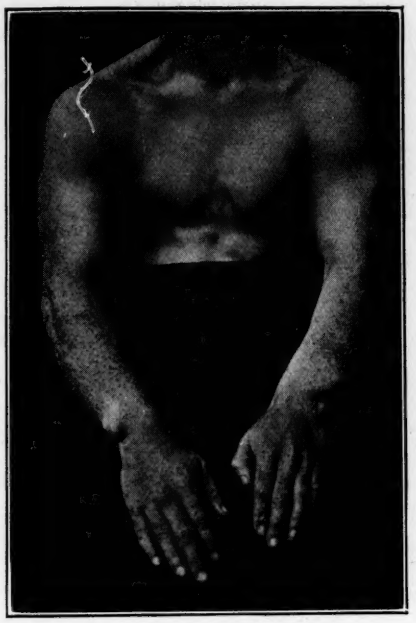

FIG. 56.—*Case* 1. Deforming chondrodysplasia. Note the enlargements of the lower end of the ulna in each forearm

FIG. 57.—*Case* 1. Deforming chondrodysplasia. Symmetrical cartilaginous outgrowths from tibiæ and femora; valgus position of feet from relative shortness of fibulæ.

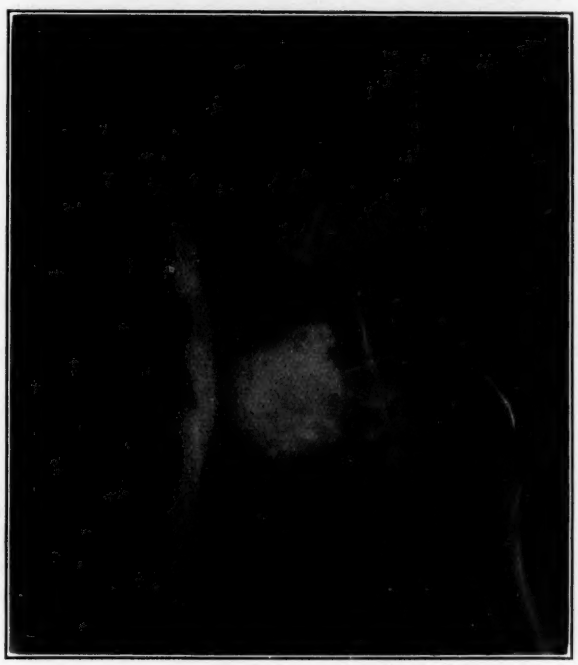

FIG. 58.—*Case* 1. Skiagram showing the 'exostosis' from the humerus, the swellings on the ribs, and the irregularities on the vertebral border of the scapula.

FIG. 59.—*Case* 1. Showing the extraordinary outgrowths from the lower end of the ulna, actually invading the radius; the relative shortness of the ulna, with increased obliquity of the wrist-joint; the freedom from similar disturbances in the metacarpus.

FIG. 60.—*Case* 1. This shows well an 'exostosis' growing from the upper end of the femur, and the extraordinary mass of irregular outgrowth from the crest of the ilium from the anterior to the posterior iliac spine.

When 18 years of age, the swellings around the right knee and hip began to cause pain on walking, so that on Jan. 30, 1917, he was admitted to hospital, and the tumours were removed from these regions. During the last few weeks he has been getting similar pain on movement of the shoulders. Previous history was negative, and no other cases have been known in the family.

EXAMINATION.—The patient is quite healthy looking, but is a partial dwarf, height only 4 ft. 6 in. There are present hard irregular bony masses of various shapes and sizes projecting from the following parts of the skeleton: (1) From the postero-internal aspect of the upper end of each humerus is a lump the size of a cricket ball (*Figs.* 55 and 58). (2) At the lower end of each ulna, growing backwards and outwards towards the radius is a rounded mass producing mechanically great limitation of radio-ulnar movement (*Figs.* 56 and 59). (3) Fusiform swellings on the fifth, sixth, and seventh ribs in the mammary line (*Fig.* 55). (4) From the vertebral borders of the scapulæ, which are concave instead of convex inwards. (5) From the crests of the ilia are projecting large irregular masses (*Fig.* 60). (6) There are scars at the hip-, knee-, and ankle-joints of the left leg; whilst in the corresponding parts of the other leg the exostoses are still present (*Figs.* 57 and 60). *Fig.* 57 shows well the flat-foot resulting from permanent eversion of the ankle-joints due to the disproportionate lengths of tibia and fibula.

OPERATION.—On May 23, 1923, the large single mass projecting from the upper portion of each humerus was removed. These were slightly pedunculated; their summits were covered with bursæ, and they were capped with a layer of cartilage; the rest of the masses were formed of soft cancellous bone. The pathologist reported them as 'ossifying chondromata'.

The most striking clinical characteristics of this case were:—

a. The symmetrical distribution of the outgrowths from the metaphyses of the long bones of the limbs that develop in cartilage.

b. The diminution of normal growth in length of the bones affected by the bony outgrowths; this has resulted in a stunting of the patient's growth in height, the condition of partial dwarfism.

c. This defect of growth in length, however, has not affected the long bones of each limb segment equally; both in the forearm and in the leg one of the two companion bones is shorter than the other. In the forearm the ulna is relatively diminished in length as compared with the radius, and ends in a curious 'arrow-head' lower extremity. It is noteworthy that, in addition, it is the ulna from which the bony outgrowths are chiefly growing (*Fig.* 59). In the leg the fibula is relatively shorter than the tibia, so that the plane of the ankle-joint is oblique and the foot is thrown into a valgus position.

Case 2.—**A case of deforming chondrodysplasia in a boy of 7 years.**

This is a case of 'multiple exostoses' in a schoolboy of 7 years. Here also there was no family history of similar cases. For a year or two his mother had noticed difficulty in fitting him with boots, on account of lumps forming on the outer sides of his ankles; but apart from this, he had suffered no disability. He came under the writer's observation owing to the detection of his disease by the school medical officer during a routine examination.

This case differs from the first in the involvement of metacarpals and phalanges in the same process of abnormal bone development (*Fig.* 63). In all other respects the only difference between the two cases is one of degree.

These cases, then, are well-marked examples of 'deforming chondrodysplasia'. Instances of this disease have apparently been noted for centuries, but it is only comparatively recently that attention has been specially directed

FIG. 63.—*Case* 2. Deforming chondrodysplasia affecting the metatarsals and phalanges as well as the lower ends of the radius and ulna.

FIG. 62.—*Case* 2. 'Multiple exostoses' around knee-joint. Note the deformation of the head of the fibula.

FIG. 61.—*Case* 2. 'Multiple exostoses' around the knee-joint: lateral view.

to it as essentially a specific disorder of bone-growth, the exostoses being merely the most obvious clinical sign of a peculiar disorder of endochondral ossification.

As far back as 1853 Sir James Paget wrote: "The last form of bony growths that I shall mention comprises the instances in which numerous exostoses occur in the same patient. Of these last we may specially observe that the tendency to osseous overgrowth is often hereditary, and that its result is a symmetrical deformity. Many similar cases of symmetrical and hereditary osseous outgrowths might, I believe, be adduced; and all their history suggests that they are to be regarded clearly as related not less closely to malformations or monstrosities by excessive development than to the osseous tumours of which I have been speaking. Indeed, at this point the pathology of tumours concurs with that of congenital excesses of development and growth."

In 1915, in the *Journal of the American Medical Association*, Ehrenfried gave a summarized account of 600 cases collected from 300 individual communications. He established it as a specific clinical and pathological entity, different from a condition of multiple tumour-formation. He showed the frequency of its hereditary and familial occurrence, and gave it the name 'hereditary deforming chondrodysplasia'.

The skiagrams of this present case would certainly seem to prove that the condition is essentially one of irregular overgrowth in width of the diaphysial cartilages, possibly due, as Sir Arthur Keith suggests, to failure of the limiting action of the subperiosteal formation of bone.

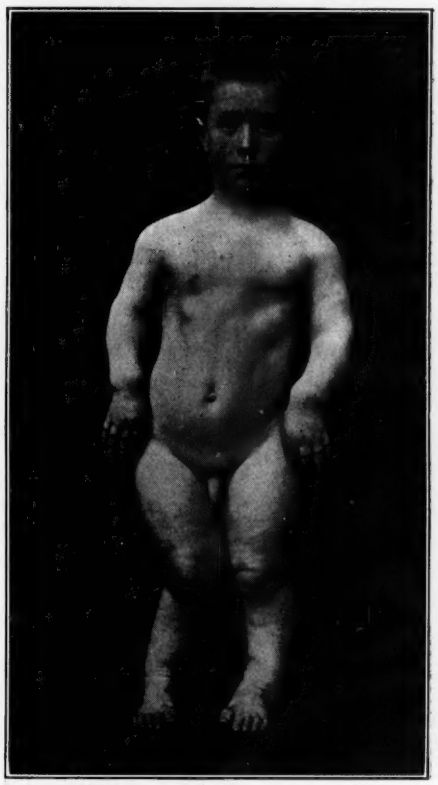

FIG. 64.—*Case* 3. Achondroplasia with deformities of the bones of the legs, necessitating the performance of osteotomies.

Case 3.—**Chondrodystrophia fœtalis (achondroplasia).**

This patient, a boy of 11 years, was admitted to hospital because of progressive difficulty in walking owing to the bowing of the bones of his legs.

He appeared quite normal at birth, but he was late in walking. When he was four or five years old his legs began to bend. Three years ago his growth, which hitherto had been very slow, seemed to stop altogether as regards his limbs. When stripped and examined he presented a typical picture of achondroplasia (*Fig.* 64). His arms and legs are very short in proportion to his trunk and head. The bilateral knock-knee, the bent legs and arms, the epiphysial swellings, the short fingers with trident hand, the deformation of the chest wall, and the lordosis are all typical. In addition, he had marked permanent limitation of extension of both elbow-joints, with very great ligamentous laxity of wrist- and knee-joints.

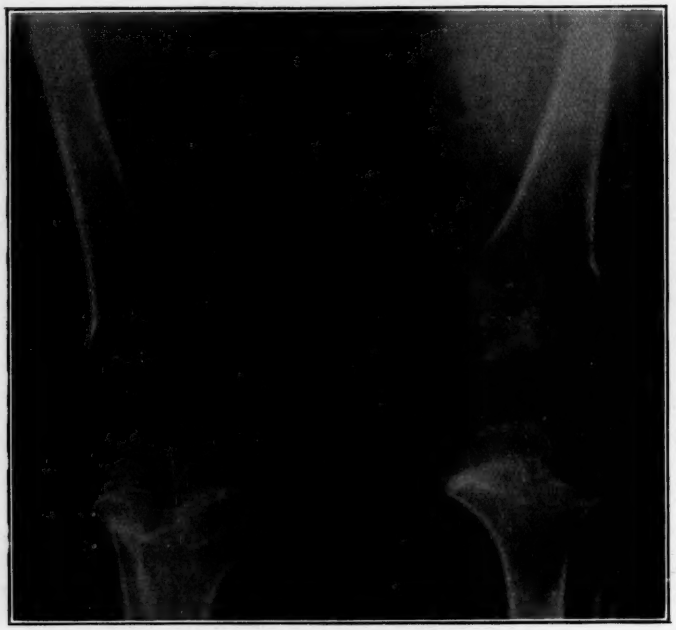

FIG. 65.—*Case* 3. Chondrodystrophia fœtalis. Marked arrest of endochondral ossification about the knee. The patella is well formed.

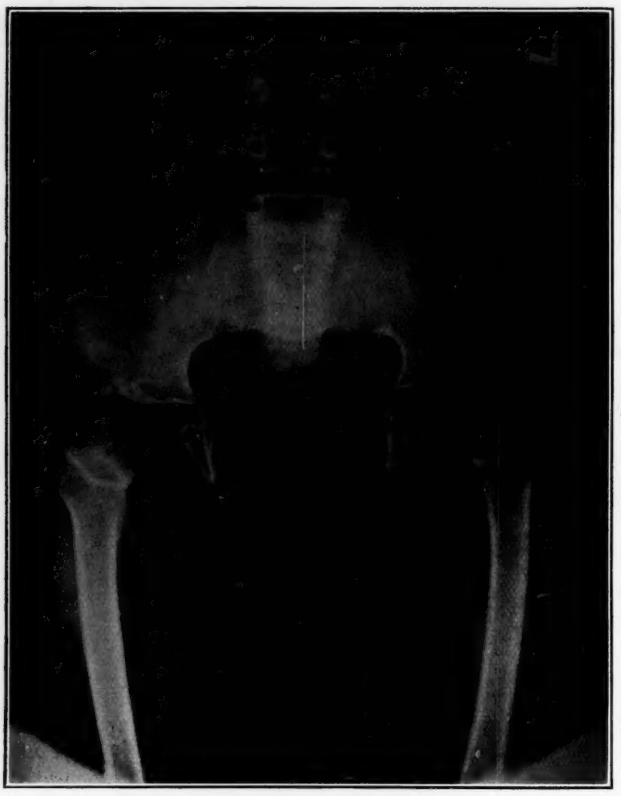

FIG. 66.—*Case* 3. Chondrodystrophia fœtalis, showing changes in the femora and innominate bones.

If *Figs.* 55, 56 and 57, and *Fig.* 64 be compared, close similarity of appearances is to be made out. Both cases present short limbs—a condition of partial dwarfism; bony swellings about the epiphysial levels of the long bones of the limbs; bending of the bones of forearm and leg; deformity of the chest, with prominent nodes at the junction of rib and costal cartilage;

FIG. 67.—*Case* 3. Chondrodystrophia fœtalis, showing the affection of the bones of the forearms and the bones of the hands, both metacarpal bones and phalanges.

and limitation of full extension at the elbow-joints. The similarity in clinical appearance is remarkable in view of the absolutely dissimilar nature of the defect in bone development as seen by comparing *Figs.* 58, 59 and 60, with *Figs.* 65, 66 and 67.

EXPOSURE OF THE HUMERUS AND FEMORAL SHAFT.

By ARNOLD K. HENRY, Dublin.

The following simple exposures of the humerus and femur seem to have escaped formal description, though doubtless the first has been used unconsciously by many. I have found them more satisfactory than the methods usually employed; they respect anatomy, give wide access, and save time.

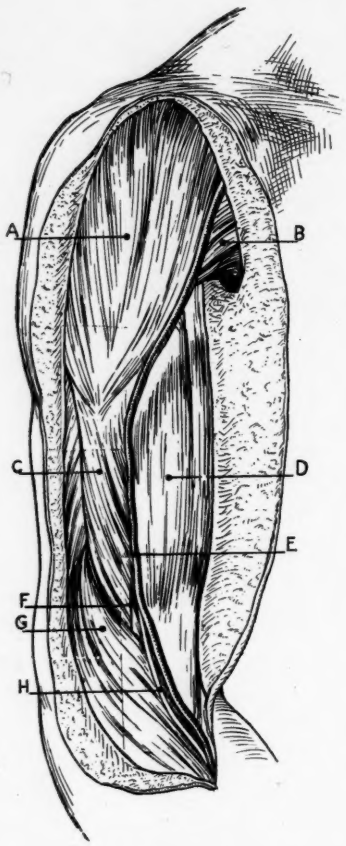

Fig. 68.—Dissection of the right arm seen from the outer side. The uncovered outer fourth of the brachialis appears between the biceps and supinator longus, and extends behind the pointed deltoid insertion. It can be used as a buffer to protect the musculospiral nerve. The occasional small branch of the musculocutaneous to the brachialis muscle is shown.

A, Deltoid. B, Pectoralis major. C, Brachialis. D, Biceps. E, Cephalic vein. F, Occasional branch of musculocutaneous to brachialis. G, Supinator longus. H, Musculocutaneous nerve.

THE HUMERUS.

Exposures as a rule define structures to avoid, or else avoid them completely: the method in question is a compromise. It lays bare the front of the humerus from end to end, leaving the musculospiral nerve protected and concealed; if further exposure is required, the nerve is directly available.

Anatomy (*Fig.* 68).—The *cephalic vein* follows the outer border of the biceps and the inner border of the deltoid, piercing the deep fascia in the lower third of the arm. It receives two or more tributaries on its outer side: these must be divided. The humeral branch of the thoracic axis artery accompanies the vein in the groove between the deltoid and the pectoralis major, and gives branches to both muscles. The inner three-fourths of the wide *brachialis muscle* are covered by the *biceps* belly (Paulet): the way to the humerus here is through the uncovered outer fourth (*Fig.* 69). The *deltoid*, arising in front from

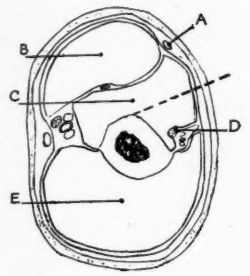

Fig. 69.—Cross-section through mid third of arm, showing the outer fourth of the brachialis left uncovered by the biceps belly. This part of the brachialis is split in the direction of the broken pointer to expose the humerus. The musculospiral is safe.

A, Cephalic vein. B, Biceps. C, Brachialis. D, Musculospiral. E, Triceps.

the edge of the clavicle's lesser curve, forms a thick unyielding curtain which gives, when pulled aside, a grudging revelation of the shoulder-joint. This is often the last successful thing it does.

The *cutaneous branch of the musculocutaneous* curves forward at the outer edge of the biceps just where the belly joins the tendon of insertion. One of its filaments is cut in the upper third of the forearm. An inconstant filament from the musculocutaneous described by Luschka and Henle, but neglected by many more recent authorities, supplies the outer fourth of the brachialis muscle in its distal part. I have found it three times in ten arms. The other branches to the brachialis are under cover of the inner portion of the upper half of the biceps belly.

The *musculospiral nerve* (the radial of the B.N.A.) runs deep in the plane of cleavage between the brachialis and the supinator longus (brachio-radialis of the B.N.A.). It reaches the outer side of the humerus one finger-breadth below the pointed insertion of the deltoid, and then curves very slightly forwards and down. Part of the nerve which lies behind the humerus is usually separated from the shaft by the pointed inner head of the triceps. The distal half of this retro-humeral portion, measuring a little more than an inch, is the only part of the nerve in direct contact with bone.

FIG. 70.—Cut through skin and deep fascia along the dotted line. (The arrow marks the 'step-down' at the acromioclavicular joint.) Expose (1) the deltoid attachment to the outer third of the clavicle, (2) the inner edge of the deltoid, and (3) the outer edge of the biceps. Continue the division of deep fascia throughout the upper third of the forearm. Split the brachialis as shown in *Fig.* 69.

The Operation.—

Position.—The patient lies with the limb close to his side and supported by the operating-table. The elbow is extended, and, when required, is flexed by an assistant.

Incision.—For exposure of the *shaft*, the skin incision (*Fig.* 70) follows the cephalic vein from the coracoid tip to the bend of the elbow, and is continued into the forearm in the mid-line of its upper third. The vein is exposed, and the outer edge of the biceps belly defined by dividing the deep fascia along its outer side.

Partial exposure of the bone may be obtained by shorter incisions, but these should never be short. Thus, to expose the distal part of the shaft, continue the incision well into the upper third of the forearm, dividing the deep fascia with blunt-nosed scissors to avoid injuring the radial artery and the cutaneous terminal (radial) branch of the musculospiral nerve: this division of the fascia allows wide retraction of the muscles.

Cut down on the humerus, first along the deltoid border; then divide the exposed outer fourth of the brachialis muscle longitudinally, a finger-breadth from the outer edge of the biceps. This cut is directed *inwards* to reach the humerus in the middle line (*Fig.* 69); it avoids Luschka's filament to the brachialis, and splits the muscle where its fibres are longitudinal. The

outer strip of the brachialis, thus separated, forms a buffer which protects the musculospiral nerve from the rugine. The nerve is not seen if the front only of the humeral shaft is exposed, and the back too can be cleared safely while the nerve is concealed; but should the surgeon wish, the musculospiral can be found one finger-breadth distal to the deltoid insertion by further mobilizing the outer portion of the brachialis and retracting it outwards and back; the nerve then appears behind the upper fibres of the muscle, and the pull on the brachialis strip removes it just sufficiently from contact with the shaft to allow the rugine safe access to the bone. The nerve is most lax when the arm is adducted and the elbow flexed through 80°; it is then most easily protected.

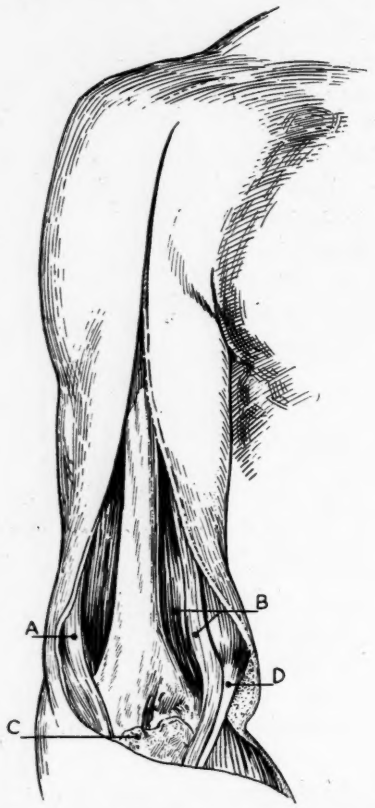

FIG. 71.—Separate the split brachialis from the bone; retract the inner and outer portions of the muscle. Relax it by flexing the elbow. The lower half of the bone is now exposed. In the figure the elbow-joint is opened and the coronoid process is seen. If exploration of the elbow-joint is not required, check the cut in the brachialis two finger-breadths above the epicondyles.

A, Brachialis (outer portion). B, Brachialis (inner portion). C, Coronoid process of ulna. D, Biceps tendon.

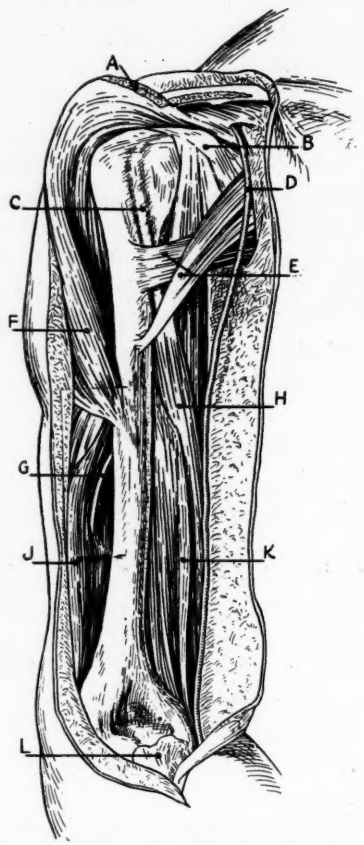

FIG. 72.—Complete the exposure of the humerus by turning the deltoid outwards on a hinged chip cut from the clavicle (*see also Fig.* 73). The musculospiral can be found, if required, by detaching the part of the brachialis which extends behind the deltoid tip.

A, Hinged chip of clavicle with deltoid origin. B, Coracoid process. C, Long head of biceps. D, Cephalic vein. E, Pectoralis major. F, Deltoid. G, Musculospiral. H, Biceps. J, Brachialis (outer portion). K, Brachialis (inner portion). L, Coronoid process.

The incision may be carried through the brachialis to within two finger-breadths of the level of the epicondyles, without entering the elbow-joint.

The bone seen through the split brachialis appears to lie at a considerable depth when the joint is extended. Flexion of the elbow to a right angle transforms this appearance, relaxing the muscle and leaving the bone widely accessible in a shallow wound (*Fig.* 71).

The front of the humeral shaft is now exposed in its entire length, completely in its lower half, but above, the deltoid yields insufficiently to retraction and gives a mere glimpse of the bone.

The Shoulder-joint.—This, with the upper part of the shaft and the tuberosities, can be exposed by continuing the skin incision outwards on the upper surface of the clavicle to the acromioclavicular joint, easily found by running the finger out along the clavicle; the finger takes, as it were, a step down at the joint (*Fig.* 70). Expose the deltoid origin by reflecting the skin. Divide the fascia and periosteum on the upper face of the outer third of the clavicle. With a chisel, detach the edge of bone which gives origin to the deltoid, as far as the acromioclavicular joint. The deltoid can then be turned outwards on a hinged piece of bone, like a sail on a spar (*Figs.* 72, 73).

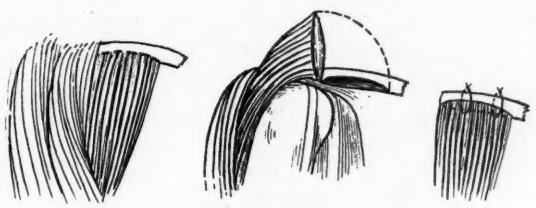

FIG. 73.—Cut the hinged chip from the clavicle along the line shown in A. B, Turn the deltoid out upon the hinged chip. C, Reconstitute the deltoid origin with two sutures which tie the chip back into place.

When the shoulder-joint has been dealt with, sutures passed through the muscle and round the clavicle lash the spar back into place, and reconstitute the deltoid origin (*Fig.* 73).

The Elbow-joint.—This joint can be opened by extending the incision through the brachialis. The tip of the coronoid process and the trochlea are at once visible; the head of the radius and the capitulum appear with adequate retraction (*Fig.* 71).

When the operation on the bone is finished, extension of the elbow, before suturing the fascia, closes of itself the wide wound in the muscle.

THE FEMORAL SHAFT.

Exposure of the femur from the outer side of the limb is popular because it does not enforce reflection; the surgeon cuts down on bone with a feeling that the femorals are safe. The inconvenient, unsightly, and bloody wound suggests, however, that security has been attained at a price, and with a certain disregard for structure. The incision transects the oblique fibres of the vastus externus, the goal of four perforating arteries, and of the large descending branch of the outer circumflex; and unless the patient is maintained in a lateral position, the surgeon works in discomfort. The method described here respects anatomy, is almost bloodless, and gives a wide and convenient exposure. Over twelve inches of the shaft, from the level of the small trochanter to the lower epiphysis, are freely available; the surgeon looks directly down on the front of the bone, and can see both sides of it in comfort.

Anatomy.—The strong fascia of the thigh is loosely attached to the thin sheaths of the rectus femoris and vastus externus. When it is divided the upper two-thirds of these muscles are easily separated by the finger, which finds the intervening plane of cleavage most easily a hand-breadth below the great trochanter (*Fig.* 74).

Near the patella the aponeurotic fibres of the vastus fuse with the rectus tendon, preventing further separation by the finger. When the rectus femoris and vastus are retracted, the silvery surface of the crureus (vastus intermedius of the B.N.A.) (*Fig.* 75) appears, and separation of its longitudinal fibres reveals the femoral shaft.

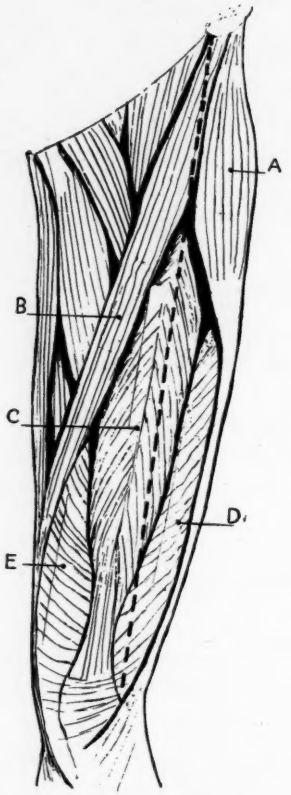

FIG. 74.—Cut through skin and fascia along the dotted line, from the anterior superior spine of the ilium to the outer angle of the patella. Find the plane of cleavage between the rectus femoris and vastus externus one hand-breadth below the great trochanter, where the rectus sinks into the angle between the sartorius and the tensor fasciæ.

A, Tensor fasciæ. B, Sartorius. C, Rectus femoris. D, Vastus externus. E, Vastus internus.

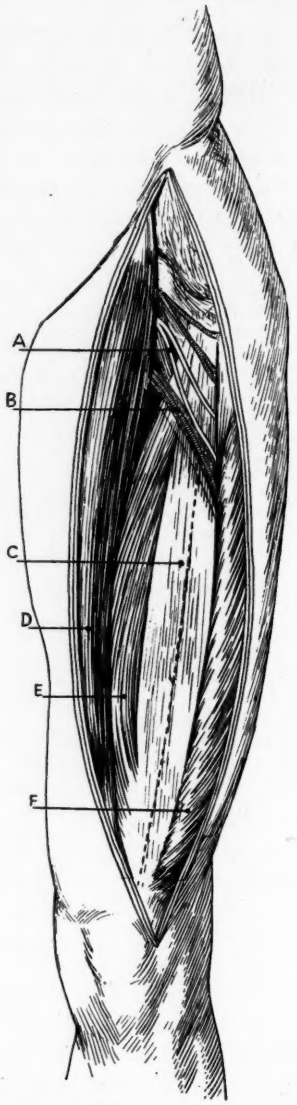

FIG. 75.—Separate the rectus femoris from the vastus externus, exposing the crureus, which is crossed obliquely by a neurovascular bundle (the descending branches of the external circumflex vessels and the nerve to the vastus externus). The artery shown above the nerve is the transverse circumflex branch lying in front of the neck of the femur.

A, Nerve to vastus externus. B, Descending branch of external circumflex artery (with veins). C, Crureus. D Rectus femoris. E, Vastus internus. F, Vastus externus.

Two structures must be considered before the bone is exposed. The first is an oblique neurovascular bundle which consists of the descending branch of the external circumflex artery, its companion veins, and the nerve to the vastus externus. This bundle is found a hand-breadth below the trochanter. The second structure, the suprapatellar pouch, extends for the same distance above the pointed extremity of the patella. As each of these must be specially dealt with by the surgeon, they will be further described with the operation itself.

The Operation.—

Incision.—The skin and deep fascia are divided along a line from the anterior superior iliac spine to the outer angle of the patella (*Fig.* 74).

Planes of Cleavage.—The finger finds the interval between the rectus femoris and vastus externus, a hand-breadth below the great trochanter, and the muscles are separated by means of the finger, which may meet one or two vessels passing to the rectus; these are caught and divided. In the lower third of the thigh the finger is checked where the aponeurotic fibres of the vastus join the rectus tendon, and the knife must be used to separate them. The blade is kept parallel to the face of the quadriceps tendon, and a plane of cleavage will be found in this trilaminar structure, between the contribution from the rectus and that from the vastus, which permits their separation down to the patella. In septic conditions, however, the laminæ of the quadriceps tendon should not be separated beyond a level one hand-breadth proximal to the apex of the patella. A small protrusion of the suprapatellar pouch sometimes pierces the tendinous contribution from the vastus externus below this level, and may be sliced open. The synovial cavity of the knee might thus be infected. When the two muscles are mobilized and drawn apart they expose the silvery surface of the crureus.

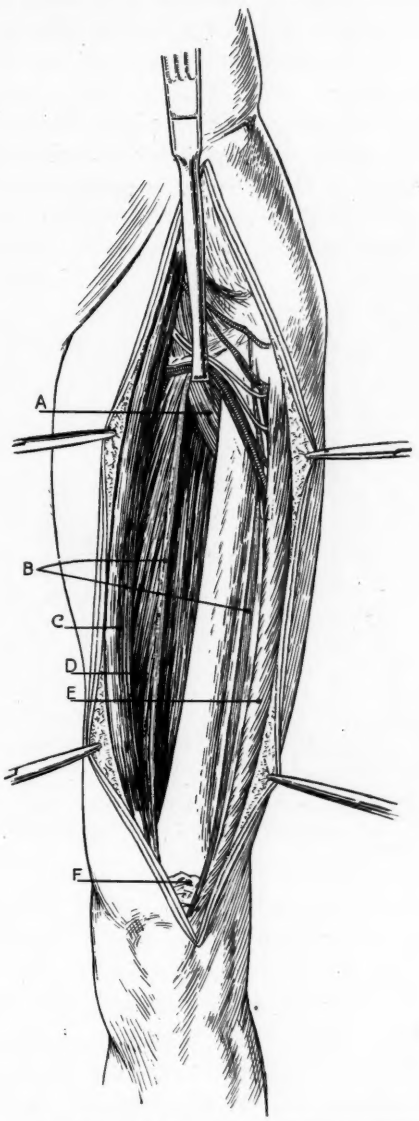

FIG. 76.—Mobilize and retract the neurovascular bundle. Split the crureus along the dotted line shown in *Fig.* 75. Avoid the suprapatellar pouch by checking the cut through the crureus one hand-breadth proximal to the pointed end of the patella.

A, Iliopsoas insertion. B, Crureus (split). C, Rectus femoris. D, Vastus internus. E, Vastus externus. F, Suprapatellar pouch.

The Neurovascular Bundle.—The oblique descending branches of the

external circumflex vessels and the nerve to the vastus externus are now seen passing across the crureus from beneath the rectus femoris to strike the free edge of the vastus externus, into which they sink. They run in a streak of fat, roofed by thin fascia, and are easily mobilized by drawing a knife along its lower edge; they are retracted proximally (*Fig.* 76). The surgeon can then cut to the bone through the upper portion of the crureus.

A large vein is often divided in this part of the muscle.

The Suprapatellar Pouch.—This, extending a hand-breadth above the apex of the patella, is easily avoided by checking the cut through the crureus above this level. The rugine works against the bone in a layer of fat, and separates the pouch from the femur.* If necessary, a retractor can be slipped between the pouch and the bone, and flexion of the thigh, relaxing the quadriceps, gives access to the lower end of the shaft.

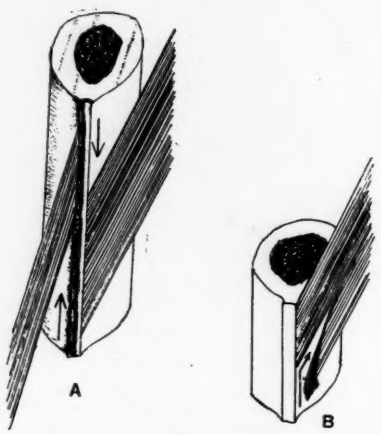

FIG. 77.—Work the rugine into the acute angle A which the muscular attachments make with the bone. B shows how the rugine tears into a muscle when used in the reverse direction against the obtuse angle.

When the two halves of the split crureus are separated from the bone and drawn apart, over a foot (32 cm.) of the femoral shaft is exposed—from the lower epiphysis to the lesser trochanter. At the inner side of the shaft the attachment of the muscles to the linea aspera is visible. If it is necessary to clear the linea aspera, the direction of the fibres should be noted; the edge of the rugine should travel into the acute angle which they make with the bone. If the rugine is used in the opposite direction, it tends to leave the bone and tear into the muscle (*Fig.* 77 B). The direction of the muscle fibres varies, of course, at the same part of the bone. Thus the adductors travel down *to* the femur, while the vasti and short head of the biceps travel down *from* the femur. These attachments are cleanly separated by proceeding with method.

The surgeon should begin on the inner side of the linea aspera. The thin origin of the vastus internus which constitutes the internal intermuscular septum (Poirier) is easily seen, and is detached from the linea aspera by working the rugine up along the shaft. The adductor insertions which form the next layer are then separated by using the rugine in the reverse direction.

On the outer side of the shaft the rugine is worked up against the origins of the vastus externus and short head of the biceps. The strong external intermuscular septum should be dealt with last; its lowest fibres are irregularly arranged, but its attachment to the linea aspera can be exposed to view by

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* Attempts at separating the pouch from the quadriceps tendon will as a rule tear the pouch. (The pouch, of course, communicates with the knee-joint.)

drawing the vastus externus towards the back of the thigh. If the surgeon then seats himself for a moment with his eyes level with the wound, the perforating vessels will be seen coming through the arched openings of the septum; and since the vessels are drawn backward in these roomy arches by retracting the muscles, they will not be injured when the septum is cut close to the bone.

Counter-openings for drainage may be made with perfect safety by cutting down on the tip of a forceps passed between the outer moiety of the crureus and the bone. The forceps follows the outer face of the external intermuscular septum, and since, in the recumbent posture, this septum is almost vertical to the bed, drainage is excellent.

In conclusion I wish to express my thanks to Professor E. J. Evatt, D.S.O, for the opportunity of working out these methods in the Royal College of Surgeons, Ireland, and to Mr. M. Barry, of the School of Art, Dublin, for his drawings of the operations.

A CAUSE FOR THE FREQUENT OCCURRENCE OF GANGRENE AFTER LIGATURE OF THE POPLITEAL ARTERY.

By JOHN S. B. STOPFORD, Manchester.

The frequency of the occurrence of gangrene after occlusion of the popliteal artery is well known, and only recently Sir George Makins[1] has stated that "injuries to the popliteal vessels enjoy a more evil reputation than those affecting any other artery of the limbs"; yet the reason for this is by no means clear. Many ingenious explanations have been advanced at various times, but a vague reference to the inefficiency of the collateral circulation is the reply most commonly received to any inquiry as to the cause for the very serious risk of gangrene after obstruction of the popliteal artery. This explanation appears to be inadequate, and particularly unsatisfactory when it is recalled that gangrene is much less frequent after ligature of the superficial femoral artery, although following this procedure the distal part of the limb must depend upon practically the same anastomoses. Makins records gangrene in 20·4 per cent after ligature of the superficial femoral, and in 45·8 per cent after injury to the popliteal.

An anatomical explanation for the very frequent incidence of gangrene consequent upon popliteal obstruction has for some time interested me, and an opportunity of studying a patient suffering from this condition, through the kindness of my colleague, Professor E. D. Telford, suggested that I should place it on record.

The patient was an electrician, age 50, who had never previously, to his knowledge, suffered a day's illness. He first came under Dr. P. R. Cooper's observation on account of the appearance of dry gangrene in the left foot and toes. There had been an absence of pain, and there was nothing to suggest a cause for the obvious arterial obstruction. The Wassermann test was negative, no evidence was discovered of cardiac or renal disease, and the blood-pressure was not raised.

After amputation through the lower third of the thigh, Professor Telford kindly permitted me to make a full examination of the limb. On opening the popliteal space an abnormal amount of fibrous tissue was encountered in the deeper part, and the vessels could not be cleared with the customary ease, which suggested some peri-arteritis. A complete obstruction of the popliteal artery, about three-quarters of an inch in length, was found at the level of origin of the inferior articular branches, and the orifice of each of these vessels was absolutely occluded. Microscopic sections through the obstructed part of the popliteal artery demonstrated the cause to be thrombosis; but histological examination of the popliteal above the level of the lesion, the superficial femoral, and the anterior tibial arteries, failed to reveal any reason for the formation of the clot.

It is difficult at first to understand the reason for the onset of gangrene consequent upon a localized, and probably gradually formed, obstruction of the popliteal artery in a patient with otherwise healthy vessels. Reference to the possible collateral circulation (*Fig.* 78) seems to suggest the only serviceable explanation. After occlusion of the popliteal artery, the blood passes from above to the patellar anastomoses through the descending branch of the external circumflex, the anastomotica magna, and more indirectly through

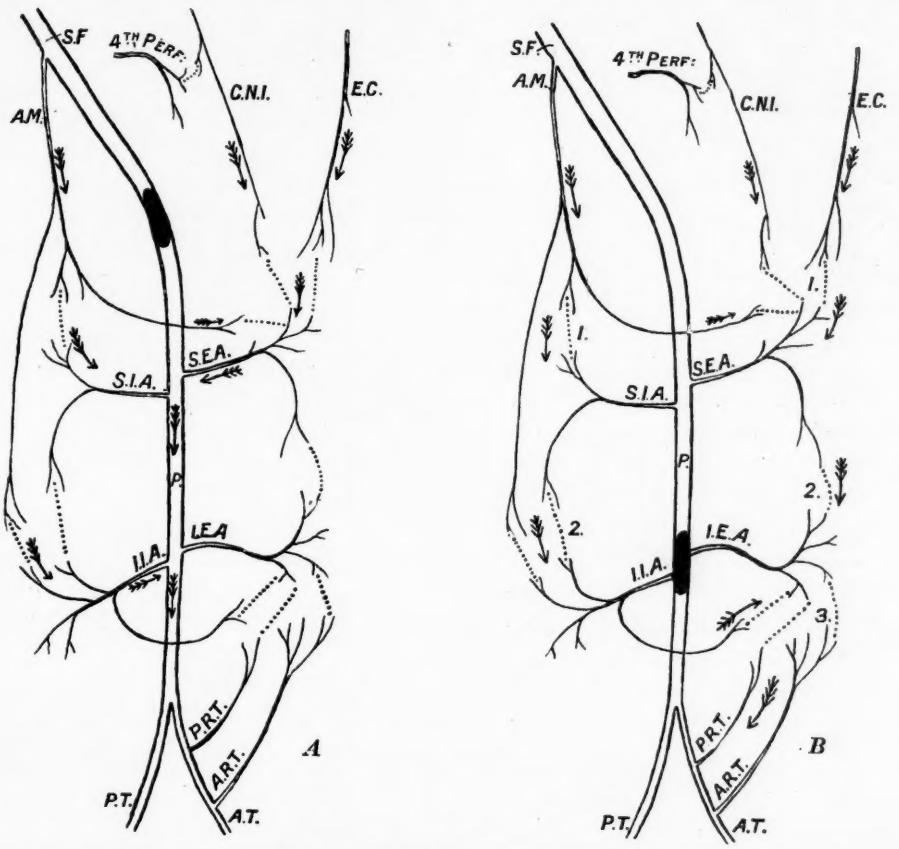

FIG. 78.—Diagrams to illustrate collateral circulation after obstruction of the popliteal artery (*A* in upper third, and *B* in lower third). S.F., Superficial femoral artery ; P., Popliteal artery ; P.T., Posterior tibial artery ; A.T., Anterior tibial artery ; E.C. Descending branch of external circumflex artery ; A.R.T., P.R.T., Anterior and posterior recurrent tibial arteries ; S.I.A., S.E A., Superior internal and external articular branches ; I.I.A., I.E.A., Inferior internal and external articular branches ; A.M., Anastomotica magna artery ; C.N.I., Comes nervi ischiadici branch of sciatic artery ; 4th Perf., Fourth perforating artery. 1, 2, 3, The three sets of arterial communications which have to be 'opened up' when obstruction occurs in the lower part of the popliteal artery.

the comes nervi ischiadici branch of the sciatic and the perforating arteries. If the obstruction occurs distal to, or at the level of, the origin of the articular branches of the popliteal, the blood can only reach the leg and foot by traversing the two recurrent branches of the anterior tibial artery. Since the latter vessels only anastomose to any extent with the inferior articular branches, the blood coming from above, in order to reach the distal

part of the limb, has to open up the fine communications between (*a*) such vessels as the anastomotica magna and the superior articular branches; (*b*) the superior and inferior articular branches; (*c*) the inferior articular branches and the recurrent tibial arteries.

This means that to provide a collateral circulation, *three* anastomoses in succession must really be opened up, and in view of this it appears less surprising that injuries to the popliteal artery are so commonly succeeded by gangrene. In fact, when the small size of the normal recurrent tibial arteries is also recalled, and the frequent irregularity of the posterior one remembered, it seems more surprising that sufficient blood to maintain the life of the tissues ever reaches the foot after ligature of the lower part of the popliteal artery.

After ligature of the superficial femoral or popliteal above the level of the origin of the superior articular branches, only one set of anastomotic communications have to be opened up, since the blood can reach the popliteal through the main stems of the superior articular branches and pass by normal channels to the leg and foot.

The figures collected by Makins thoroughly support the view put forward in this paper, as he discovered that, in injuries to the popliteal artery, the situation of the wound considerably influenced the occurrence of gangrene. In 60 cases he found gangrene in 20 per cent when the injury affected the upper third (which is most probably above the origin of the superior articular branches), in 40 per cent in the middle third, and in 35 per cent in the lower third. These percentages show—as my explanation would lead us to conclude—that the occurrence of gangrene is only as frequent after obstruction of the upper third of the popliteal artery as after obstruction of the superficial femoral, but if the course from the articular branches through the popliteal to the anterior and posterior tibial arteries is impeded, the risk of gangrene is very markedly increased.

REFERENCE.

[1] MAKINS, G. H., *On Gunshot Injuries to the Blood-vessels*, John Wright & Sons Ltd., Bristol, 1919.

'MESENTERIC CYSTS': WITH A REPORT OF TWO CASES.

By T. TWISTINGTON HIGGINS and ERIC I. LLOYD, London.

The first known case of a mesenteric cyst was described by Benevieni, the Florentine anatomist, in the 16th century. Since that time about 250 cases have been published, chiefly by surgeons. These cysts are found rarely, and their etiology is so uncertain that it seems worth while to record the following example which occurred recently in the hospital practice of one of us (T. T. H.). The opportunity has been taken to describe at the same time a second case which, though clinically very different, presents points of similarity to the first which we think suggest a close relation between the two, or at least constitute a useful parallel. We propose to describe these cases in detail, to give a short summary of current views on the etiology, symptomatology, and treatment of mesenteric cysts, and to discuss the relationship between the two cases and such views.

CASES.

Case 1.—C. O., a boy, 5 years old, was admitted to the Hospital for Sick Children, Great Ormond Street, on May 24, 1923, suffering from an undiagnosed abdominal swelling. The history given by his parents, who were well educated, was that the child was 'perfectly well' until three weeks before admission, when a swelling was accidentally discovered in the left side of the abdomen. This swelling was entirely symptomless, and they had noticed no change in the child beyond slight irritability and a tendency to tire easily. His appetite was normal, he was not getting thinner, and there was nothing to suggest implication of the alimentary or urinary tracts.

On Examination.—The child was normal except for his abdomen, which was enlarged asymmetrically. A very large mass could be felt occupying the whole of the right side of the abdomen, passing across the mid-line into the left umbilical and lumbar regions. It was distinct from the liver and spleen, and its surface was smooth. It felt tense, but not definitely cystic, and was immobile. The swelling was painless on examination, and dull on percussion, except where intestine lay in front of it. X rays demonstrated a retroperitoneal tumour pushing the intestine forward, but nothing abnormal could be felt per rectum, and the blood and urine were normal. Dr. R. S. Frew reported that the heart and lungs were also normal. An exact diagnosis could not be made, but a sarcoma of the right kidney and an encysted tuberculous peritonitis were considered possible.

Operation.—Exploratory laparotomy was carried out (T. T. H.) on May 31, and the swelling exposed through a right rectus incision. During the operation 14 oz. of citrated blood were given intravenously. The swelling was found to be a very large unilocular cyst lying retroperitoneally behind the termination of the superior mesenteric artery; this artery and its accompanying vein were stretched across the cyst, which lay between the ascending colon on the right and the small intestine on the left (*see Fig.* 79). Complete removal was obviously impossible, so the cyst was tapped, and 35 oz. of turbid brown odourless fluid, shimmering with cholesterin crystals, were removed. Below the main cyst and in the ileocæcal angle of the mesentery were many thin-walled smaller cysts the size of a split pea and

containing a clearer fluid. These were probably simple dilated serous spaces in the mesentery caused by the pressure of the tumour. It was decided that marsupialization was the only feasible method of treatment. Accordingly the cyst wall was freely incised, the contents were completely evacuated, and the cavity was sponged out with gauze ; finally the edges of the opening were accurately sutured to the lower half of the abdominal wound. A large drainage tube was inserted into the cavity of the cyst, and the upper half of the abdominal wound was closed in the usual way. At subsequent dressings the cavity was plugged with gauze soaked in flavine in liquid paraffin in the hope of inducing intracystic adhesions.

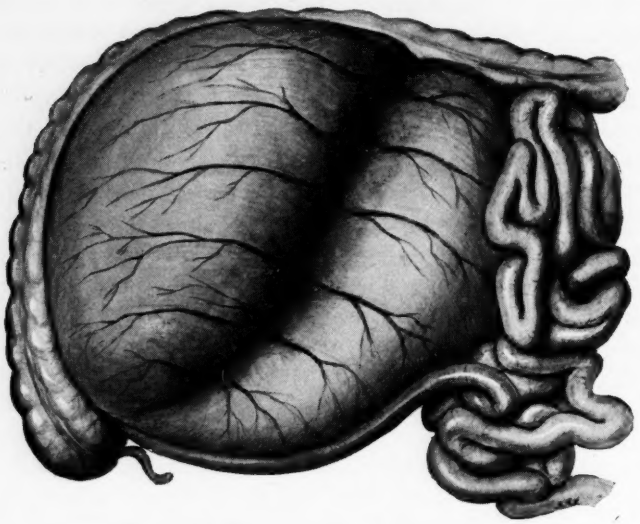

FIG. 79.—Mesenteric cyst (diagrammatic).

The child made an uninterrupted recovery, and was discharged on July 30. He was seen a month later, and was then quite well ; the wound was firmly healed ; there was slight thickening to be felt beneath the scar, but the abdomen was otherwise normal on palpation. He was seen again in April, 1924, when his condition was excellent.

PATHOLOGY.—The fluid removed from the cyst showed the characters usual in these cases, and the report was as follows : "Very bloodstained, specific gravity 1217, no trypsinogen, etc., no sugar or bile pigment, albumin present more than 4 per cent". The sediment was chiefly blood, and the fluid was sterile on culture. A section of the cyst wall showed "a thick wall of fibrous tissue with an endothelial lining".

The features we wish to emphasize in this case are : the large size of the tumour, its lateral position and immobility, the doubt whether it was solid or cystic, and the presence of secondary smaller cysts.[1, 2, 3] In other respects it was true to type, even in that a correct diagnosis was not made before operation.

Case 2.—(We are indebted to Mr. H. J. Waring for permission to publish this case.) C. C., a married woman, 45 years of age, was admitted to St. Bartholomew's Hospital on Jan. 28, 1921, with a history that eighteen years previously she had noticed a lump in the abdomen. This was said to have been diagnosed as oöphoritis ; the swelling was thought to have disappeared, and the patient remained quite well until 1911, when the swelling reappeared. In August, 1920, there was a sudden

increase in its size, accompanied by discomfort but not by acute abdominal pain; there were never any urinary symptoms; she had complained of irregular menstruation with increased loss since 1911.

EXAMINATION.—On inspection of the abdomen there was a visible swelling in the right hypochondriac and right lumbar regions, the size of an ostrich's egg. It was fluctuant, there was a band of resonance between it and the liver, and on palpation the swelling could be distinguished from the liver. Although cystoscopy showed both kidneys to be working normally, it was thought that she was suffering from a right-sided hydronephrosis.

OPERATION.—On Feb. 1, 1921, an exploratory operation was performed through a right lumbar incision by Mr. Harold Wilson. A large cystic swelling was found lying in the perinephric tissue in relation to the upper pole of the right kidney. It was not attached to the kidney or suprarenal body, and lay outside the tunica propria of the former. Seven pints of greenish-brown fluid were evacuated through a cannula, and the cyst wall was dissected out and removed. The wound was drained for twenty-four hours, and was healed when the patient left the hospital three weeks later.*

PATHOLOGY.—A section of the cyst wall showed "purely inflammatory structure with no evidence of renal tissue". The fluid removed at operation possessed a greasy sheen and contained cholesterin crystals. Its specific gravity was 1020, the reaction was neutral, and the fluid coagulated spontaneously on standing. On culture it proved to be sterile. It contained red blood-corpuscles and a considerable quantity of albumin, and effervesced with sodium hypobromite.

Although the last statement is evidence of the presence of urea, it does not prove that the fluid in the cyst was derived from urine: it is well known that the blood, cerebrospinal fluid, saliva, and probably most of the other body fluids contain urea, but that the percentage in urine is five to ten times that in the blood (20 to 40 mgrm. per cent in health). We have no quantitative figures on the interesting question whether the cyst contents were in this respect nearer blood or urine, nor has this point been investigated, so far as we know, in other cases. The only observation we have found in this relation is that of Jones,[4] who found urea 0·3 per cent in fluid from a mesenteric (not pararenal) cyst. This is, approximately, the same as in blood. The case we have described was labelled 'pararenal cyst', but its exact pathology remained in doubt.

GENERAL REMARKS ON MESENTERIC CYSTS.

ETIOLOGY.

What is meant by the term Mesenteric Cyst?—It often happens, when a condition of obscure origin is under consideration, that the nomenclature and classifications in general use are as diverse and unsatisfactory as the attempts to explain the disease, and it is certainly so with mesenteric cysts. Broadly speaking, any cyst occurring between the layers of, or in close relation to, the mesentery might be included under the heading 'mesenteric'. Thus, many of the published classifications embrace a variety of cysts (e.g., hydatid, malignant, and dermoid) whose only common attributes are their cystic character and intramesenteric position. Hæmatomata of the mesentery, which

* On Nov. 11, 1923, the patient wrote that she was perfectly well.

may follow injury in the absence of a pre-formed cyst, certainly account in rare instances for mesenteric tumours, but they are not true mesenteric cysts and only call for consideration in differential diagnosis. Such adjectives as lymphatic, chylous, sanguineous, though frequently used, merely denote accidents which may befall any cyst, and though picturesque they have no precise bearing on the problems of etiology and serve no useful purpose. It is therefore necessary to extract from the general mass common to all classifications the group of what may be called 'true' mesenteric cysts, for it is with this group only that we are now concerned. Before proceeding to this, it is convenient to consider some of the classifications which have been suggested, and three of the simpler and more recent of these are given below.

1. In 1900 Dowd[5] published an important paper and adopted the following :—

a. Embryonic cysts.
b. Hydatid cysts.
c. Cystic malignant disease.

This was amplified by Ayer,[6] who added two more groups :—

d. Cysts arising from the glandular structure of the intestinal wall.
e. Cysts of the normally placed retroperitoneal organs.

2. Niosi[6] in 1907 subdivided Dowd's embryonic group thus :—

a. Cysts of intestinal origin : By sequestration from the bowel during development ; From Meckel's diverticulum when it arises from the concave side of the gut.
b. Dermoid cysts.
c. Cysts which spring from retroperitoneal organs (e.g., germinal epithelium, ovary, Wolffian or Müllerian bodies).

3. A more recent classification, that of Carter,[8] though evidently based on Dowd's, is as follows :—

a. True mesenteric cysts : Embryocystomata ; Enterocystomata ; ? Obstructive.
b. Dermoids.
c. Cystic malignant disease.
d. Parasitic.

We are not here concerned with parasitic or cystic malignant disease, and they may be dismissed. So also may true dermoids ; but it is interesting to notice in passing that no retroperitoneal or mesenteric dermoids have been reported in the male,[6, 9] though they have occurred in the testis,[6] which is originally a retroperitoneal organ ; this has been held as evidence that an ovary is responsible for the true dermoid when it occurs in the mesentery.

True Mesenteric Cysts.—We have now restricted our field to those cysts which occur in or near the mesentery and which are not malignant, dermoid, or parasitic, and do not arise in any normally placed retroperitoneal organ. It is to the origin of these that we must now turn our attention. They have been found at every time of life, from the fœtus to 80 years of age, though most commonly from 10 to 20 years, and occur in both sexes, with a slight preponderance of female over male. They are usually found

near the terminal portion of the ileum, though they have also been described in the mesentery of the jejunum, the cæcum, and appendix, and all parts of the colon; at least one occurred in close relation to the stomach.[10] Of 28 cases published between 1900 and 1912, all were in the mesentery of the small bowel, with a proportion of ileum to jejunum of about 3 to 1.[11]

The cyst often possesses an epithelial lining, though this is by no means invariable, and in a large cyst is frequently destroyed, presumably by the internal pressure exerted upon its walls; in one specimen the lining epithelium remained only here and there.[12] When present it is generally of simple columnar type, but may be stratified, or rarely ciliated.[11] The wall of the cyst varies in thickness and composition; fibrous tissue predominates, but there may be a few unstriped muscle fibres or occasionally a complete reproduction of the structure of some part of the alimentary tract (*vide infra*). The typical fluid[13] from a mesenteric cyst is "a pale, clear, straw-coloured fluid of specific gravity 1015 or 1016, contains a large amount of albumin, and is alkaline in reaction". Blood, cell débris, and cholesterin are also usually present. Multiple cysts are rare, though cases have been recorded, by Makins[1] amongst others.

What is the origin of these cysts?

1. Lymphatic.—For many years the accepted idea was that they arose from obstruction and subsequent dilatation of a lymph-vessel in the mesentery. This view has been largely discarded in England and America, but, until recently, had its adherents in France.[13, 14]

2. Wolffian Remnant.—In 1900, Dowd[5] reintroduced and elaborated the suggestion that these cysts are due to inclusion of remnants of the Wolffian body in the developing peritoneal folds. Eight years previously, Braquehaye[15] had stated that "they" (i.e., congenital mesenteric cysts) "may come from rests of the Wolffian body", and had referred as authority to Auganeur's *Thèse d'Agrégation* (Paris, 1886); but it was Dowd's paper that focused attention upon the subject. Dowd gave instances of sequestration in many organs, and concluded that these cellular relics behind the peritoneum might push their way between the leaves of the mesentery, and—liable as they are to undergo cystic degeneration—might give rise to cysts in the position in which they are usually found. He attributed the origin of most true mesenteric cysts to this developmental accident, but admitted that some might arise as diverticula from the intestine. This view has met with general favour and has been widely accepted, though some writers[12] regard the developmental error as primarily "an anomaly in the coalescence of the peritoneal mesenteries". Niosi[7] described a case in which he found nodules of suprarenal tissue in the walls of a mesenteric cyst, but this would be more illuminating if it were not, as it seems to be, a unique observation. The fact that the cyst is so often solitary appears to us to afford definite support to the view of their origin held by Dowd.

3. Diverticula.—

a. Intestinal.—There is, however, good evidence that some of these cysts arise as diverticula from the intestine; these are enterogenous cysts, and constitute the group of 'cysts of intestinal origin' in Niosi's classification (p. 98) and the 'enterocystomata' in that of Carter (p. 98). This is a serious

rival to the 'embryonic' view, and requires further notice. It has been shown that intestinal diverticula occur regularly in the embryo of the pig, rabbit, and man. In one human embryo of 23 mm., Lewis and Thyng[16] found 33 'pockets', and in an older specimen 48. These were all diverticula of the small intestine, and in no human embryo did these authors find them along the border of the large intestine or vermiform process. Again, Wallmann[17] found 37 diverticula in a piece of small intestine 48 cm. long, and 30 of these were between the layers of the mesentery; but he also found some present in the large intestine. The duodenum is perhaps the commonest situation, and it is said that diverticula here occur frequently.[18] Since intestinal diverticula do occur in the human embryo, it requires no great imagination to suppose that, lying between the layers of the mesentery, they might become separated from their origin and form true mesenteric cysts.

Miller's case[11] seems to prove that this does occur: a female infant of four days died from a volvulus caused by a mesenteric cyst whose lumen did not communicate with the gut, but whose wall was directly continuous and identical in composition with the small intestine, from which it had undoubtedly arisen as a diverticulum. Other good examples of enterogenous cysts are given by Hunter[19] and Van der Bogert.[2] It may be difficult in some cases, where a few scattered plain muscle fibres are present in a wall of a cyst, to decide whether or not it is enterogenous; but when a regular arrangement of muscle fibres at right angles to one another can be demonstrated, and when the structure of the alimentary canal is exactly reproduced, even to the presence of villi on the inner wall of the cyst, there is a very strong presumption that it arose in this way.

b. Meckel.—Cysts might arise enterogenously in a second way, from a persistent Meckel's diverticulum, or from a persistent portion of the vitelline duct. This is a structure whose position varies, for it may "originate from any part of the gut and apparently from any aspect" (Miller, loc. cit.); but its average situation is stated to be 43 inches proximal to the ileocæcal valve. Although Meckel's diverticulum is present in only 2 per cent of individuals, there is no authority for thinking that microscopic remnants of the duct are as rare. In order that this explanation may be applied to cysts between the layers of the mesentery, it is necessary that the duct should have arisen on the concave side of the intestine.

Thus, if the enterogenous cysts be considered to arise both as intestinal diverticula and as growths from vitelline duct remnants, a situation "in the upper bowel would favour the former, and in the lower bowel the latter" (Miller, loc. cit.). This statement can only be applied to cysts arising in the true mesentery, but it is exceptional to find them elsewhere. In a recent paper in the BRITISH JOURNAL OF SURGERY, MacAuley[20] described a case of congenital ileocæcal cyst, and gave particulars of ten others dating from 1886 which he regarded as forming a definite group. In his example the cysts were almost all near the ileocæcal angle, and probably most of them arose from the ileum. It seems possible that these are enterogenous cysts which have pushed their way into the lumen of the gut. Their walls seem similar to those of the enterogenous cysts cited above, and Ayer's case,[6] which MacAuley gives as one of his series, was anatomically outside the cæcum.

MacAuley, however, distinguishes them from other mesenteric cysts, though he does not consider their pathology. Professor Sir Arthur Keith, who reported on the specimen, regards it as an enterogenous cyst, but does not discuss its relation to mesenteric cysts.

Summary.—

1. True mesenteric cysts are not malignant, parasitic, or dermoid, but form a separate group in which are included the majority of all 'mesenteric cysts'.

2. Their origin is still in doubt, but it seems probable that there are two classes :—

a. Cysts of embryonic origin arising from mesodermal remnants incarcerated behind the developing peritoneum and subsequently migrating forward between its layers.

b. Cysts of intestinal origin : (i) Arising in most cases as diverticula from the bowel during development ; (ii) Possibly derived sometimes from persistent portions of the vitelline duct.

3. Some anomalous and hitherto unclassified cysts, such as the 'pararenal' example described as *Case* 2, are true mesenteric cysts which have developed from mesodermal remnants behind the peritoneum, but which, unlike the ordinary clinical mesenteric cyst, have not moved anteriorly into the developing peritoneal folds.

It is important to distinguish the cysts of which we speak from the large cysts of the kidney which occur generally singly and quite apart from chronic nephritis, congenital cystic disease, and echinococcus infection ; these are cysts of the kidney substance proper, and may communicate with the pelvis or contain fluid closely allied to urine, whereas the pararenal variety is definitely outside the kidney, and, though they may indent its substance, are not attached to it, and contain the characteristic fluid previously described. Pararenal (or paranephric) cysts are very rare, and have received scant notice in the text-books. There is no mention of them in *Keen's Surgery*, and only a lew lines in some of the standard works on urology. Thus, Morris, Garceau, Thomson-Walker, and Kidd all refer briefly to them, and allude to a possible origin from Wolffian body remnants ; but no attempt seems to have been made to associate them particularly with mesenteric cysts, nor does their close resemblance, and that of their contents, to mesenteric cysts seem to have received due notice.

SYMPTOMATOLOGY AND DIAGNOSIS.

The clinical aspects of these cases are of considerable surgical interest, and accord with the size, situation, and character of the cyst. Quite often the picture is that of a symptomatically silent abdominal tumour, though if this is of large size there may be associated discomfort. On the other hand, signs of subacute intestinal obstruction may be present, viz., attacks of distention associated with colicky abdominal pain and vomiting. In either case acute symptoms may supervene at any time, and then indicate the onset of obstruction due to any of the complications. The classical clinical sign is the *tumour* ; this corresponds in position to the anatomical site of the

mesentery, and is, generally, more or less central in position. It is smooth, rounded, and cystic, though this last point may not be easily determined in the case of a tense cyst felt through the abdominal wall. In the typical example the mobility of the tumour is the striking feature, and this is usually greater in the transverse than in the vertical direction, in accordance with its mesenteric attachment. General wasting is not a characteristic of the condition, even when a large tumour is present and obstruction of the lacteals might be expected.

The differential diagnosis may be considered briefly under two heads: (1) Diagnosis from other intra-abdominal tumours; (2) Diagnosis between individuals cysts.

In a typical case the situation, mobility, and general characters of the tumour may localize it with probability to the mesentery, and serve to distinguish it from other abdominal swellings, e.g., ovarian or kidney tumours. Its cystic character may also be clear, but even then the exact nature of the tumour can only be surmised. It should usually be possible to exclude parasitic and malignant cysts; but a tuberculous abscess in the mesentery may present all the features enumerated above, and indeed, in childhood at any rate, is the most common type of 'mesenteric cyst' to be exposed by operation!

An Italian writer[21] has made the following pathetic pronouncement on the subject of the diagnosis of mesenteric cysts: we give Braquehaye's French translation: " Sans se torturer autant et inutilement l'esprit, la seule chose à faire est une laparotomie exploratrice ".

Though it is admittedly a very difficult diagnosis to make, yet there are cases where, once suspected, a mesenteric cyst should be diagnosed. Obviously the attempt ought always to be made.

COMPLICATIONS.

Because of their surgical importance it is necessary to enumerate the complications to which these cysts are liable. Often enough it has been at operation on a puzzling 'acute abdomen' that the existence of an unsuspected mesenteric cyst has been revealed.

1. Intestinal obstruction is the most frequent and the most serious of the common complications. In a small series[11] of 17 enterogenous cysts, acute obstruction occurred in nearly 50 per cent, whilst the group mortality of 35 cases of obstruction due to this cause was 35 per cent. The methods by which it may be brought about are mechanical, and include volvulus, intussusception, kinking, adhesions, and a narrowing or occlusion of the gut by pressure of the tumour or stretching of the intestine over it.

2. Peritonitis, when it occurs, is a sequel to the above.

3. Hæmorrhage into the cyst has caused death.[14]

4. Rupture of the cyst may also cause death (Timbal, loc. cit.); but there are two cases of recovery[22, 23] following what seems to have been spontaneous rupture of the cyst into the bowel.

5. Torsion of the cyst.

6. If a mesenteric cyst occupies the pelvis, it may itself become impacted, or may give rise to symptoms varying with the organ upon which it presses.

TREATMENT.

It has been stated above that spontaneous recovery has followed rupture of a mesenteric cyst; nevertheless it is clear that surgical treatment is called for in every case, even though an exact diagnosis may not have been made before operation. The treatment required is governed by the urgency of the case, thus:—

1. **The Acute.**—This comprises the abdominal emergencies which may be due to any of the complications already enumerated; treatment in such cases follows the ordinary lines without necessarily permitting an attack on the causal cyst.

2. **The Subacute or Chronic.**—In this group are the ordinary uncomplicated cases; these require an operation for the removal of the cyst, or, if this is impossible, some procedure which will relieve symptoms and give hope of cure. The following methods have been used:—

a. Aspiration.—This is no longer practised except as a stage in more radical operations.

b. Enucleation of the Cyst.—This is the ideal treatment, but is not always possible.

c. Resection of the Involved Segment of Intestine.—Partial resection is sometimes necessary to extirpate a cyst, but it is a severe undertaking, and in these cases carries a mortality of 60 per cent.[11]

d. Drainage by Marsupialization.—The cyst wall is sutured to the abdominal parietes, and some operators, hoping to induce adhesions and obliteration of the cavity, apply caustics to the wall of the cyst.

Certain objections have been raised against enucleation and marsupialization; these may be set out as follows:—

Objections to Enucleation.—(*a*) That it is a more difficult and dangerous operation than marsupialization; (*b*) That it is sometimes impossible to accomplish because of extensive adhesions, the large size of the cyst, or its intra-intestinal position; (*c*) That it is liable to damage the intestinal vessels and nerves; (*d*) That it may injure the solar plexus. We have been unable to find statistics on the operative mortality sufficiently recent to be of value. Braquehaye, in 1892, gave that of enucleation as 40 per cent, and of drainage as 6 or 7 per cent; but Miller (loc. cit.), in 1913, records ten enucleations without a death, and simple drainage must nowadays have a very low mortality.

Objections to Drainage by Marsupialization.—(*a*) That the cyst wall is not removed and that there is consequently no guarantee of cure; (*b*) That convalescence is long and a persistent sinus may result; (*c*) That post-operative complications are liable to follow, notably intestinal obstruction. The first and third would be serious disadvantages if they occurred at all frequently; but cure is almost invariable, and post-operative complications are extremely rare.

Summary.—

a. Either simple enucleation of the cyst or marsupialization of its wall, and drainage of the cavity, should be practised in every uncomplicated case.

b. Enucleation is the operation of choice, but only when it can be done without resort to intestinal resection.

c. Marsupialization and drainage should be performed in the remaining cases. It is an old operation—Péan in 1880 is said[15] to have been the first to establish it as the appropriate surgical treatment for mesenteric cysts—but it is easy, safe, and universally applicable.

Care should be taken not to overlook undrained loculi or secondary cysts, and strong caustics should not be used.

CONCLUSIONS.

1. True mesenteric cysts are to be distinguished from other cysts found in the mesentery; their occurrence in this situation is not a topographical accident (cf. hydatid and malignant disease), but bears an important relation to their etiology and pathology.

2. To this group belong the greater number of mesenteric cysts.

3. Their origin is still in doubt, but the evidence that some true mesenteric cysts are enterogenous and arise primarily as diverticula of the alimentary tract is very strong and must be accepted.

4. The view which attributes the origin of enterogenous cysts to persistent remains of the vitelline duct is a possibility, although one restricted by the anatomical position of the duct. It cannot at present be considered proved.

5. The embryonic (Wolffian body remnants) explanation is attractive and applicable to a mesenteric cyst irrespective of its position. This view rests only upon strong probability, and is, by its very nature, difficult of proof; nevertheless it appears to us to afford the most plausible explanation of the origin in the majority of cases.

6. These cysts are diagnosed with difficulty, but they are amenable to surgery, although they are liable to cause complications which greatly increase the danger to life.

7. The first of the two patients whom we have described was found to have a typical though large mesenteric cyst. In the second the cyst was near the upper pole of the right kidney, though it was clearly not attached either to the kidney or to the suprarenal body; its macroscopic and microscopic characters were identical with those of a mesenteric cyst. We suggest that this also was an example of so-called mesenteric cyst, and that it arose from remains of the Wolffian body, and hence came to occupy a situation in close relation to the kidney. If it is admitted that this cyst, which bears such a close resemblance to the mesenteric cysts, arose in this way, then it seems to lend additional support to Dowd's explanation of the origin of mesenteric cysts.

8. Whether or not this is so, the term mesenteric cyst is a bad one, even when applied to the true cysts which we have discussed. Cunéo[12] in 1909 suggested 'paraperitoneal' as an improvement in nomenclature, and, if further

investigation should reveal a common pathology for some of the ill-defined varieties of retroperitoneal cysts, it may be that this word will be usefully employed in a wider sense than its author intended.

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ON THE ATTEMPTED PRODUCTION OF AN 'ASCENDING' RENAL INFECTION IN RABBITS.*

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It was shown by one of us (D.) in a previous communication[1] that, using the *Staphylococcus aureus*, it was an easy matter to bring about an infection of the kidney in the rabbit by way of the blood-stream. The present series of experiments was undertaken with the view of ascertaining if it were possible to bring about an 'ascending' infection of the kidney, using the term in the sense of an infection passing with the urine by a reversal of the usual direction of flow from the bladder into the ureter and thence into the renal tubules. The *Staphylococcus aureus* having, for reasons stated in the report, been used in the previous investigation, was also made use of in the present instance.

The problem naturally divides itself so as to fall under two heads: (I) The possibility of infection of the ureter from the bladder; and (II) The ureteric infection being established, whether it can pass by way of the lumina of the tubules into the kidney.

Various workers have obtained results indicating that fluid may pass from the bladder into the ureter with comparative ease. Thus Lewin and Goldschmidt[2] using milk, and Courtade and Albarran[3] using Indian ink, reported that regurgitation took place from the bladder into the ureter in rabbits; and Kretschmer[4] reported filling of the ureter from the bladder, demonstrable by X rays in four out of eleven children investigated. These results seemed to indicate that infection of the ureter from the bladder should be an easy matter. Such, however, was not found to be the case.

I. ATTEMPTED INFECTION OF THE URETER FROM THE BLADDER.

The first step was to produce a cystitis; this proved more difficult than was anticipated. The simple injection of organisms into the bladder was first tried.

Experiment 1.—One c.c. of a thick emulsion of *Staphylococcus aureus* in broth was injected by means of a glass catheter into the bladder of a male rabbit. Specimen of urine obtained by catheterization twenty-four hours later showed no pus-cells, but gave a free growth of the organism on culture. Seventy-two hours later a further specimen showed a diminished number of colonies on culture; *one week* later organisms were absent from the urine.

The experiment was repeated on several occasions and, although the length of time during which the organisms remained present in the urine

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differed in individual cases, the results were all substantially the same. The organisms disappeared from the urine in a few days, and none of the animals treated in this way showed any signs of illness.

Simple introduction of organisms into the bladder having proved a failure, so far as infection of that viscus, much more so of the ureter, was concerned, the question of applying trauma to the bladder with the hope of rendering it more susceptible to infection was next considered. The introduction of turpentine has been shown by various workers to be a highly successful agent for this purpose. The effects of this irritant are well described by David,[5] and it is obvious from his account that the damage to the mucous membrane produced by it is such as to render infection of the blood-stream from the lumen of the bladder an easy matter. Since it was particularly desired to avoid any possibility of infection by this route, this agent was not employed. An attempt was made to provide a reservoir of organisms in the bladder, so that the viscus would be submitted to a continuous inoculation, the organisms in the reservoir being out of reach of the protective mechanism of the bladder wall. To this end a piece of porous earthenware soaked in an emulsion of living staphylococci was inserted into the bladder; but this was found to produce excoriation of the mucous membrane, which again introduced the possibility of spread of infection by the blood-stream. Choice was finally made of a piece of soft Turkey sponge. The following is typical of several experiments:—

EXPERIMENT 2.—Under ether anæsthesia the bladder was exposed by a suprapubic incision and opened transperitoneally through its anterior superior surface. The urine was swabbed out, and a piece of Turkey sponge about the size of a pea when compressed, but capable of expanding to about 2 cm. in diameter, was introduced. Ten drops of a thick emulsion of staphylococci in broth were allowed to fall upon the sponge, by which they were at once absorbed without having come in contact with the edges of the wound in the bladder wall. The bladder was then sutured with a seromuscular stitch, the suture line being covered by a small peritoneal fold containing fat, and the suprapubic wound closed.

Forty-eight hours later the rabbit appeared in fair health. Urine withdrawn by catheterization contained pus-cells and gave staphylococci on culture. On the fifth day from operation the animal was killed. On opening the bladder, which was contracted and contained very little urine, the sponge was not found, having apparently been voided; the mucous membrane was very swollen and œdematous; the ureters, kidneys, and all other organs showed nothing unusual, either to the naked eye or microscopically. Pus-cells were present in such urine as could be obtained from the bladder, and it gave a free growth of staphylococci.

It might have been anticipated that the above method of incising the bladder wall transperitoneally and then inserting a living culture of organisms would almost certainly give rise to peritonitis, or infection of the bladder wound, or both, with a consequent blood infection. It was hoped, however, that the organisms would remain in the sponge for an hour or so, and would not be diffused by urine all over the bladder, until the wound had had time to become sealed by clot. The success of this method was shown in practice in that, although the experiment was performed some six times for one reason or another, in no instance did the peritoneum become infected, and in only one did an abscess form in the bladder wound; this last case is described more fully later (*Experiment* 6).

The above experiment was repeated twice, and always with substantially the same results. In every instance an inflammation of the mucous membrane was produced, though in no instance was the sponge found in the bladder post mortem. Apparently the presence of the foreign body containing organisms in its mesh, even for the short time that it was in the bladder, was capable of rendering the mucous membrane susceptible to infection by the coccus. In every instance sections of the ureters and kidneys were cut and examined microscopically, but beyond some cloudy swelling in the tubular epithelium of the latter, no evidence of infection could be detected.

With a view to demonstrating the organism, if present at all in the kidneys, these were, in one case, removed immediately after death and incubated overnight in a sterile Petri dish; sections were then cut and examined for organisms. In the previous investigation one of us (D.) had found this to be a particularly successful method of demonstrating living cocci when present in the kidney, but in this case there was a negative result.

As it might be objected that sufficient time had not elapsed for infection to pass from the bladder to the kidneys, a vesical infection was produced in two rabbits (*Experiment* 3) in the manner described above, and the animals were allowed to survive. Pus-cells and organisms had disappeared from their urine by the *tenth day*, and, at post-mortem at the end of a month, the kidneys of both were perfectly normal.

The above experiments showed that, whatever may be the case as to passage of urine from the bladder back into the ureters, the production of infection in this way does not occur readily, if at all. David thought that he secured evidence of infection in this way; but, as pointed out above, he used turpentine to render the bladder susceptible to infection, thereby opening the road for blood-borne infection to take place. It is noteworthy that Draper and Braasch[6] could find no evidence of regurgitation from the bladder into the ureter, even when considerable pressure was used, and after slitting up the mouth of the ureteric opening in the bladder wall. They attached even more importance to the sphincteric activity of the lower end of the ureter than to the valvelike arrangement of the opening of the ureter into the bladder.

Carmine Injection into Bladder.—In one experiment a tentative effort was made to effect the passage of an easily recognizable inert substance from the bladder into the ureter, as follows:—

EXPERIMENT 4.—Under ether anæsthesia the bladder of a large rabbit was exposed; it was found dilated with urine; 1 c.c. of a thick emulsion of carmine was introduced by means of a catheter, and the urethra ligated. The abdominal incision was temporarily closed, and the animal kept under light ether anæsthesia for four hours. At the end of that time the bladder was again exposed, and found to have become considerably more distended with urine. The ureters showed no signs of dilatation. The rabbit was killed and, in order to prevent any relaxation of the vesico-ureteric opening after death, plunged at once into Kaiserling's solution. When thoroughly fixed, the bladder and ureters were opened. No trace of carmine staining was present in either ureter, indicating that, in spite of the tension in the bladder caused by obstruction of the urethra, no regurgitation of the urine had occurred.

Such a single experiment cannot be conclusive, but it agrees with the findings of Draper and Braasch.

Effect of Trauma on Susceptibility of Kidney to Infection of Bladder.—Attention was now directed to the effect of trauma in rendering the kidney susceptible to infection from an infected bladder.

A subtle form of trauma seemed to be offered by temporary or permanent occlusion of the ureter. Lepper,[7] using *B. coli*, found that, although organisms injected into the blood-stream in the dosage used by her did not, under ordinary circumstances, make their appearance in the urine, they did so if the ureter of one kidney were temporarily occluded; this she believed to be due to trauma caused to the kidney by even temporary closing of the ureter. Some evidence as to the nature of this trauma is given later. The following experiment was performed:—

EXPERIMENT 5.—Under ether anæsthesia the ureter was exposed through a median abdominal incision, and a bulldog clip applied at about its middle. The wound was then partially closed, but in such a manner as to leave the handle of the clip protruding, and 1 c.c. of an emulsion of staphylococcus was introduced by catheter into the bladder. The wound with the clip protruding was covered by a sterile dressing, and the animal left for one hour. At the end of that time the clip was removed and the wound finally closed. Forty hours later urine removed by catheterization showed no pus-cells and gave only a few colonies of staphylococci on culture. Thereafter specimens of urine showed nothing abnormal.

This experiment was repeated once. On killing the second rabbit, some scarring and consequent contraction of the ureter at the site of application of the clip, but insufficient to cause complete occlusion, was found; the ureter above this point, and the pelvis, were both somewhat dilated, but there was no sign of infection of the kidney.

On the assumption, which as subsequent experiments showed was not justified, that any trauma to the kidney produced by obstruction of the ureter would be progressive, it was now determined to infect the bladder, to give the infection ample time to reach the lumen of the ureter, and then to ligate that structure. It was hoped that the disturbance produced by the obstruction of the ureter would be effectual in bringing about a renal infection.

EXPERIMENT 6.—In the manner described above, a cystitis was brought about by the introduction of infected Turkey sponge. Five days later, under ether anæsthesia, and through a median incision, the left ureter was ligated in two places and a portion removed from its middle. The wound was then closed. Eight days later the animal, which for some days past had shown signs of illness, was killed. At autopsy the left kidney was found to be greatly enlarged and to show collections of pus beneath the capsule; the pelvis and ureter were both enormously dilated on section, the dilated pelvis was found to be filled with pus, and areas of suppuration were apparent tracking through the kidney substance from pelvis to capsule, under which were several abscesses of all sizes. Three septic infarcts were to be seen in the substance of the kidney (*Fig.* 80).

Cultures of pus from the left pelvis gave a free growth of *Staphylococcus aureus*; cultures from the heart blood and right renal pelvis were sterile. From the bladder urine, staphylococci were grown.

On opening the bladder, an abscess was found surrounding the sutures in the wall of the organ.

In this experiment a severe infection of the kidney had been brought about; as to the mode of this infection, there were two possible explanations. In the first place, it might be assumed that the cocci had made their way from the bladder into the ureter before it was ligated, and that after occlusion of that structure they had produced the infection of the kidney, weakened as a result of the operation. This explanation is hardly probable, inasmuch as the segment of ureter removed five days after the bladder was infected was quite normal on microscopical examination, indicating that no infection was present in the ureter at the time that structure was ligated. In the second place, the renal infection might be explained as having been borne from the abscess in the bladder wall by the blood-stream. The presence of septic infarcts in the kidney offered support to this second view.

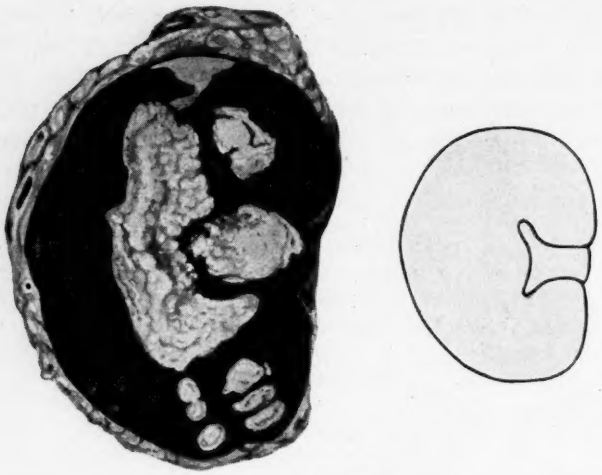

FIG. 80.—Abscess formation in *Experiment* 6. Outline figure shows size of unaffected kidney.

This experiment was repeated, and in three other experiments (7, 8, and 9) the infection of the bladder was brought about at the same time, two days and one week respectively prior to the occlusion of one ureter. *Experiments* 8 and 9 were each performed twice. In none of these further experiments was an infection of the kidney procured, and in none of them was any infection of the operative wound in the bladder present, such as was described under *Experiment* 6.

Early Changes in Kidney following on Occlusion of Ureter.—At this point it seemed desirable to obtain some first-hand information as to the more immediate effects of occlusion of the ureter upon the kidney. In *Experiments* 10 to 15, the ureter was exposed under ether anæsthesia through a median incision and a ligature applied at the junction of the lower and middle thirds. This procedure was carried out without in any way touching either the kidney itself or its vessels. The importance of this is indicated hereafter. The abdominal wound was then closed, and the animals were allowed to survive for one hour, two, three, and five days, and one and two weeks respectively. In every instance the animal was killed at the end of the time stated, the kidney removed at once and put into Kaiserling's solution, and only sectioned after it had become hard.

EXPERIMENT 10.—Animal killed one hour from time of obstruction of the ureter. On cutting open the kidney after fixation, the pelvis and ureter were found greatly dilated. The renal papilla was flattened out and the medulla compressed, but the cortex showed no diminution in thickness. On microscopical examination the most striking change was the presence of numerous areas of hæmorrhage; these

were most plentiful in the cortex and boundary zone, and appeared to be due to the rupture, following upon overfilling, of the intertubular capillaries; the presence of great engorgement of the veins in conjunction with comparative emptiness of the arteries suggested obstruction of the venous outflow as the cause of these hæmorrhages. So far as could be ascertained, this obstruction was due to pressure exerted by the tense walls of the greatly dilated pelvis upon the arcuate system of veins in the kidney. The tubules of cortex and medulla alike were greatly dilated, obviously as the result of the pressure of the secreted urine within them.

EXPERIMENT 11.—Animal killed twenty-four hours from time of ligation of the ureter. Macroscopically the appearances were very similar to those in *Experiment* 10. The walls of the pelvis were greatly swollen and dark red in colour, and the urine retained in the pelvis was dark brown and contained many red blood-cells. Microscopic examination showed no increase in the areas of hæmorrhage described under *Experiment* 10, but in other respects they revealed a further advance of the state of affairs seen after one hour's ligation; the dilatation of the tubules, more particularly those of the cortex, was greatly increased; the medulla showed further signs of the influence of the pressure exerted by the contents of the dilated pelvis, the tubules in this area, as they approached the papilla, showing a sharp bend due to the stretching of the medulla and flattening of the papilla; this bend had apparently resulted in the occlusion of the tubules, thus, to a large extent at any rate, cutting off the lumina of the cortical tubules from any direct connection with the cavity of the pelvis.

EXPERIMENTS 12, 13, 14, 15.—Ureter obstructed for three, five, and seven days, and two weeks. Macroscopically these all showed the same features as described under *Experiments* 10 and 11. The pelvis showed little increase in size in any of these experiments on that attained after twenty-four hours' obstruction; the substance of the kidney itself, however, showed a slowly progressive dilatation, accompanied by great stretching and flattening of the medulla, though even after two weeks' obstruction a deep strip of cortex remained, spread out over the dilated renal sinus. After the third day the venous congestion became progressively less and less, while the areas of hæmorrhage had completely disappeared at the end of a week—apparently as the result of absorption. By the end of two weeks the dilatation of some of the tubules of the cortex had become extreme; others were compressed and had their lumina occluded; the compressed tubules tended to occur in well-defined areas, mapping out the areas in which dilatation of the tubules had occurred, the result of this arrangement being to give a honeycomb appearance to sections of the cortex as viewed through a hand lens. This progressive dilatation of the tubules speaks for a continued secretory activity on the part of the kidney, the urine thus secreted being to a large extent retained in the tubules as the result of the flattening of the medullary tubules and their angulation, as pointed out under *Experiment* 10. The cells of the dilated cortical tubules were flattened, but otherwise appeared healthy; the epithelium of the compressed tubules also stained well, but in some of the tubules the basement membrane had disappeared, presumably indicating the first step towards the dissolution of these tubules. The glomeruli showed no dilatation.

The above experiments show that the most striking of the more immediate effects of obstruction of the ureter on the kidney is not, as might be expected, the onset of a progressive degeneration of the secreting tissue, but, on the contrary, an almost immediate, sudden trauma in the shape of interstitial focal hæmorrhages, with a strong tendency to recovery. In order to be sure that these hæmorrhages are due directly to ligation of the ureter, it is, of course, essential to ligate that vessel as is described above, without handling the kidney. Any such method as delivering the kidney through a loin incision preparatory to ligating its ureter produces extensive hæmorrhages and masks

the effect of the ureteric ligature. This production of traumatic hæmorrhages must be borne in mind in all experiments upon the kidney involving ligature of the ureter, and, taking it into consideration, the most probable explanation of the infection of the kidney in *Experiment* 6 would seem to be that it was carried by way of the blood-stream from the abscess in the bladder to one of the hæmorrhagic areas in the renal substance.

II. INFECTION OF THE KIDNEY FROM THE URETER.

Attempts at producing an 'ascending' infection of the urinary tract from the bladder having given only the above negative or equivocal results, attention was now directed to the possibility of the passage of infection from the ureter into the kidney.

EXPERIMENT 16.—Under ether anæsthesia the ureter was exposed through an abdominal incision and ligated at the junction of the lower and middle thirds. A glass cannula was inserted into the proximal end of the ureter, and the ureter divided below the point of insertion of the cannula. The proximal end and cannula were brought out through the abdominal wound, which was then sutured and sealed with collodion; 1 c.c. of an emulsion of staphylococcus was introduced through the cannula into the ureter, the ureter ligated just above the cannula, and the latter removed. The introduction of organisms into the ureter was carried out in this way to avoid contamination of the peritoneal cavity, which in no instance occurred. Forty-eight hours later the animal was killed. The kidney was found greatly swollen, with numerous and extensive subcapsular abscesses about the lower pole; in fact the condition closely resembled that of 'surgical kidney', with the difference that owing to the ligature of the ureter the pelvis was greatly dilated with pus.

The problem now was to determine whether the infection had 'ascended' in the strict sense of the term by way of the lumina of the tubules into the renal substance, or whether infection of the kidney had been the result of direct spread into the interstitial tissue; the appearances of abscesses under the capsule, while the main mass of pus was confined to the pelvis, suggested that a real 'ascent' of the infection might have occurred. Microscopic sections, however, did not confirm this view; these showed the medulla stretched out and compressed by the mass of pus and urine in the pelvis; the epithelium of the tubules in immediate relationship to this pus was necrotic, apparently as the result of spread of toxin into the tissues, the necrosis grading off into degeneration, and then into cloudy swelling, as the neighbourhood of the pus was left. In places the infecting cocci, by reason of the dissolution of the epithelial lining of the renal sinus, had gained access for a very short distance into the interstitial tissue of the medulla; but nowhere could pus-cells or cocci be demonstrated in the lumina of the tubules.

The abscesses under the capsule at the lower pole were found to be due to the direct spread of the infection from the pelvis through a rupture in the epithelium of the sinus, where it was reflected from the pelvis on to the papilla, and thence up under the capsule, without affection of the underlying cortex. It was conjectured that this rupture had been brought about by the use of too great an amount of emulsion for the injection, and of too great force in

its performance. This was confirmed in a further experiment (*Experiment* 17), in which only 0·2 c.c. of the staphylococcal emulsion was used; in this case, although the same infection of the pelvis was produced, the subcapsular abscesses were absent.

Carmine Injection into Ureter.—Since experiments with living cocci necessitated the early destruction of the animal, and moreover produced progressive changes of a rather uncontrollable nature, they were repeated using a suspension of carmine; the use of this material made it possible to leave the animal for as long as wished after its introduction, in order to give ample time for it to find its way from the pelvis into the kidney, were it capable of so doing.

In the first of these experiments, Nos. 18 and 19, 1 c.c. of the carmine, used in a heavy emulsion in distilled water, was introduced into the left ureter, which was thereafter ligated, in the manner described above; the animals were killed twenty-four and forty-eight hours respectively from the time of the injection. In both cases the appearances after death were very similar; but, since they were more striking in the rabbit which had been allowed to survive for forty-eight hours, this alone will be described. At post-mortem,

FIG. 81.—Mode of spread of carmine from pelvis out under the capsule in *Experiments* 18 and 19.

the pelvis and ureter as far as the ligature were found greatly dilated and filled with carmine; at the lower pole of the kidney was a deeply stained area caused by the appearance of the carmine beneath the capsule (*Fig.* 81). On laying the kidney open after fixation, it was apparent that this subcapsular staining had been produced by the direct passage of the carmine from the pelvis, out beneath the true renal capsule, without its having entered into the substance of the kidney at all. Macroscopically the kidney showed the usual flattening of the medulla, but no evidence of carmine within its substance.

On microscopic examination it was at once evident that, as in the first experiments in which living cocci were used, the amount of the injected material had been too great and that rupture of the epithelium lining the renal sinus had been effected (*Fig.* 82). It was through such a rupture that the carmine had passed out from the pelvis beneath the capsule covering the lower pole of the kidney. Microscopic examination of the sections showed rupture of the epithelium, not only at the junction of the pelvic wall and capsule, but also over the surface of the kidney bounding the renal sinus. At some of these points of rupture of the epithelium hæmorrhage had occurred, and in one of them a mixture of red corpuscles and carmine granules was to be

seen actually lying within the interstitial substance of the kidney (*Fig.* 83). Further examination of this kidney revealed granules of carmine lying within vessels, sometimes free, sometimes contained within the lining endothelium, and in many cases at some considerable distance from the site of the hæmorrhage; it was not possible in every instance to be sure if the vessels concerned were lymphatics or capillaries; some were undoubtedly blood-vessels, and the probability is that both were implicated. Furthermore, a number of the convoluted tubules in the immediate neighbourhood of the carmine-

FIG. 82.—Reflection of epithelium of renal sinus from papilla (B) on to pelvic wall (A); the arrow shows site of rupture in *Experiments* 18 and 19.

containing hæmorrhagic areas showed numerous minute granules of carmine within their lining epithelial cells (*Fig.* 84). In no instance was a granule of carmine detected within the lumen of a tubule, though some of the tubules contained a pinkish homogeneous substance (*Fig.* 84, **A**) which may have been albumin stained by carmine secreted in solution in the alkaline urine and coagulated by the fixative. These appearances might seem to indicate that the carmine had been taken up by the blood or lymph or both from the carmine-containing hæmorrhagic area, and was in course of being excreted

by the tubular epithelium; a more probable explanation is that the appearances were due to vital staining of the bioplastic granules of the epithelial cells by the carmine.

Whatever may have been the manner in which the carmine granules reached the epithelium of some of the convoluted tubules, it was quite evident that none of it had reached the interior of the kidney by passage from the pelvis up the lumina of the tubules.

FIG. 83.—Bursting of carmine through epithelium of renal sinus and into interstitial tissue of kidney in *Experiments* 18 and 19. Hæmatoxylin stain.

A further experiment, No. 20, in which only 0·3 c.c. of the emulsion was used and the animal was left for five days in order to give the carmine every opportunity of passing from the pelvis into the kidney, confirmed this view. In this animal no rupture of the epithelium of the renal sinus was found post mortem, and, although the pelvis was full of the emulsion, no trace of it could be detected in the kidney, either macro- or microscopically.

Burns and Swartz,[8] using dogs, report that they found no difficulty in bringing about the passage of Indian ink from the ureter into the kidney.

They state that in animals killed half an hour from the time of the injection under a hydrostatic pressure of six inches of a small amount of this substance into the ureter, they were able to demonstrate the ink " in the collecting tubules, the distal convoluted tubules, the ascending and descending limbs of Henle's loop, the proximal convoluted tubules, the capsule of Bowman, in the spaces between the tufts of the capillaries of the glomeruli, and in the capillaries themselves".

FIG. 84.—High-power drawing of portion of *Fig.* 83 within circle, showing carmine-stained granules in epithelial cells. A, The pink substance referred to on p. 114.

The difference between these findings and those given above in connection with carmine injections is so striking that it was considered necessary to repeat the experiment, using Indian ink, with a view to ascertaining if there is any radical difference in the behaviour of the two substances.

In *Experiments* 21 and 22 Indian ink was allowed to flow by gravity from a height, in the one case of 6 inches, in the other of 9 inches, into the ureter, which had been cannularized. The pressure was kept up for half an hour, the animal being all the time under light ether anæsthesia. At the end of

this time the ureter was ligated, the animal killed, and the kidney removed and fixed. In both cases the findings were identical. The pelvis was filled with the ink, but the most careful microscopical examination failed to show the entrance of a particle of the injected material into the tubular system of the kidney.

DISCUSSION.

The uniformly negative result of all the experiments described above, performed with the view of bringing about the passage of cocci or carmine granules, or Indian ink, from the pelvis into the renal tubules, points to the conclusion that the renal papilla stands guard over the tubular system of the kidney, acting as a valve, passage through which in the reverse direction is a matter of impossibility. If the results described above are correctly interpreted, it would seem that an 'ascending' infection of the kidney, in the sense of the passage of infection from the pelvis into the renal tubules, can never take place.

In *Experiments* 16, 18, and 19, however, the possibility of infection of the kidney from the pelvis in a manner other than the direct passage of infected urine in the reverse direction into the renal tubules was demonstrated. These experiments showed that by a sudden increase of the fluid pressure within the pelvis it was possible to effect a rupture of the epithelium of the renal sinus. Such a rupture occurring at the junction of the pelvic wall and renal capsule allowed the passage of the pelvic contents outwards underneath the capsule, and in the presence of an infecting agent might give rise to a condition indistinguishable from a clinical 'surgical kidney'. It is probable that an increase in the pressure within the pelvis, to a height sufficient thus to bring about a rupture of the epithelium lining the renal sinus, could only be caused by a mechanical injection such as was used in the experiments. It is possibly conceivable that such an effect might be produced by a sudden stoppage of the urinary passages such as may occur with a stone in a ureter; but even that is conjectural. There can, however, be little doubt that in therapeutic irrigation of the pelvis through a ureteric catheter it would, by the use of sufficient force, be easy to bring about such a rupture of the epithelium of the sinus. It seems quite possible that exacerbations of renal infection such as are sometimes seen following on pelvic irrigation may be due to this cause. The experimental results provide indications for caution in so far as the volume of irrigation fluid used and the degree of pressure under which it is injected are concerned.

SUMMARY AND CONCLUSION.

A series of experiments is described, designed, if possible, to bring about an 'ascending' infection of the kidney, using the term 'ascending' in the sense of an infection passing into the kidney via the lumina of the urinary passages. Attempts directed to bring about infection of the ureter from the bladder showed that the uretero-vesical junction offered, under the experimental conditions, an insuperable bar to the passage of infection from the bladder upwards. By direct infection of the lumen of the ureter it was found

to be possible to bring about a subsequent infection of the kidney; but this infection was due, not to regurgitation of the infected pelvic contents into the renal tubules, but to direct spread through the epithelium of the renal sinus into the interstitial substance of the kidney, and under certain conditions, into the space between the kidney and its true capsule. Carmine injected into the pelvis did not pass through the renal papilla, which appeared to offer an impassable barrier to a reversal of the urinary flow.

No evidence could be obtained of the possibility of the occurrence of an 'ascending' renal infection.

The thanks of the authors are due to Sir Cuthbert Wallace, Director of the Surgical Unit, St. Thomas's Hospital, and to the Medical Research Council, without assistance from which the work could not have been carried out.

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RETROPERITONEAL CYSTS: THEIR PATHOLOGY, DIAGNOSIS, AND TREATMENT.

By R. M. HANDFIELD-JONES, London.

(Being the Hunterian Lecture delivered at the Royal College of Surgeons of England on Wednesday, Jan. 23, 1924.)

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I. INTRODUCTION.

It may perhaps be said with some justice that retroperitoneal cysts are of academic rather than practical interest; but I believe that they are of some importance, for several reasons. First, it will be generally agreed that the study of embryology is not sufficiently often referred to in dealing with the etiology of disease. We touch lightly, and not always very accurately, upon embryological facts for the explanation of such conditions as hare-lip, cleft palate, thyroglossal and branchial cysts; but there are undoubtedly many more complicated problems upon the etiology of which embryology may be expected to shed further light; and I am convinced that we are on the threshold of much important work based on the correlation of embryological and pathological methods. Many retroperitoneal cysts are developmental in origin, and I hope to show how a study of the processes involved sheds considerable light upon their origin. Secondly, these cysts are not common, and in the past but little work has been done upon them, and the literature on the subject is most confusing.

My attention was first directed to them by a case in St. Mary's Hospital, in 1920, and, as is the experience of us all, examples of rare diseases do not

come singly but in twos and threes. Three cases of retroperitoneal cyst were admitted within two months, and since then none have been seen, though I have personal knowledge of two others. The first case was impressed on my mind partly because of its intrinsic interest, partly because it was the first case of its type I had seen, and partly because it provided a dramatic diagnostic surprise. It may be conveniently quoted here, as it gives a graphic picture of these retroperitoneal cysts.

Case 1.—Female, 34, married, with two children, was admitted to St. Mary's Hospital with a history of vague pains in the left side of the abdomen. She had had a certain amount of trouble with the bowels for the previous month, necessitating the use of purgatives twice a week, but we were not satisfied that this was of any importance. She had also had frequency of micturition for about three months, which she described as coming in regular attacks with quite normal intervals. On examination, a swelling was found in the left side, being freely movable and easily reduceable into the loin. It was soft, rather flabby, and obviously cystic in nature, and I think quite naturally a diagnosis of hydronephros was made. A pyelogram was accordingly taken, but unfortunately the plate was thin, and no definite expression of opinion could be hazarded upon it. It was, however, suggested that the solution seemed to have filled a very small part of the renal pelvis.

An exploratory operation was decided upon, and the left oblique lumbar incision performed. When the perirenal space was exposed, a bluish thin-walled cyst was found, and the diagnosis of hydronephrosis seemed assured. As the dissection proceeded, the surgeon remarked that the ureter would soon be found attached to the hydronephrosis. But the cyst shelled out revealing no attachments at all, and it was then realized that the kidney was present, rather higher in the abdomen than usual, and moreover was only half the normal size, thus explaining the unusual pyelogram.

This case illustrates in many ways the features characteristic of retroperitoneal cysts. The need exists for an accurate definition of the term 'retroperitoneal cyst', for so many cases are so named which are cysts of organs such as the kidney, pancreas, and so on. They are naturally situated behind the peritoneum, but I submit that the term should be reserved for those cysts lying in the retroperitoneal fatty tissues which have no apparent connections with any adult anatomical structure save by areolar tissue.

In this paper I shall deal with such cysts as I have defined above, except that I have a few remarks to make on some falsely-named pancreatic cysts, and also on two cystic conditions in the kidneys which are of developmental origin and are very closely related to the whole question of the true retroperitoneal cyst. I shall therefore outline quite briefly the embryological processes which are relevant.

II. DEVELOPMENT OF THE STRUCTURES OF THE POSTERIOR ABDOMINAL WALL.

1. **The Pronephros.**—The human pronephros has no excretory function, and can only be regarded as a rudimentary structure. Its appearance is but transitory, and its development is so incomplete that a clear idea of its life history is by no means easy to obtain, especially as it occurs in so very early a stage in the growth of the human embryo, being first seen in a 1·73-mm. embryo and having completely disappeared by the time the 4·9-mm.

stage is reached. A detailed account of its development would be quite out of place here, but certain of its salient features must be emphasized.

In lower forms the excretory system is essentially a segmental one, and the same tendency is seen in the arrangement of the human pronephros and mesonephros. The segmentation of the mesoderm begins at the head end of the embryo and proceeds caudally until complete. Pronephric rudiments have been seen by Felix[7] and others in the 2nd primitive segments (*Fig.* 85). The cranial portion develops first, and so brief is the existence of the tubules that those first formed are already in an advanced stage of degeneration when the caudal ones are appearing. These latter are completed in an embryo of 2·5 mm. greatest length, and are already degenerated in one of 4·25-mm. vertex-breech length.

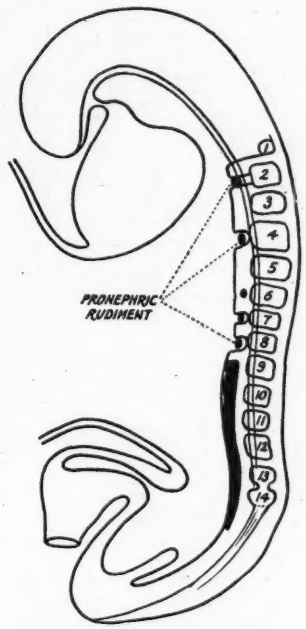


FIG. 85.—Diagram showing the left pronephric elements in an embryo of 2·6 mm. greatest length, with 14 pairs of segments. There are pronephric rudiments in the 2nd, 4th, 6th, 7th, and 8th, and the ridge from the 9th to 13th primitive segments. (*Modified from Felix.*)

For the purpose of this paper two points are of the utmost importance, viz., the most caudal extension of the pronephric system, and the time of its complete disappearance. It is probable that no pronephric tubules exist beyond the 12th primitive segments, though there is some doubt about the 13th pair. The 12th segments will eventually correspond in the developing embryo with the opening of the bursa omentalis, and therefore pronephric remnants—if they persist—will be behind the peritoneum and are in a position to account for cyst-formations. In this connection it is instructive to remember that in the dogfish there are certain papillary projections from the posterior wall of the bursa omentalis, which Professor J. E. S. Frazer has described, and to which he has given an undoubted pronephric value. The time of disappearance of the pronephros is impossible of accurate determination, because in the caudal segments there is an overlapping of pronephric and mesonephric elements, and the picture is somewhat confused; but it may be said with some confidence that by the time the 5-mm. vertex-breech length stage is reached, the pronephros has disappeared. Nevertheless it is important to remember that the external glomerulus of the pronephric tubules may persist long after this stage, because of their independence.

2. **The Mesonephros.**—The development of the mesonephros is a vast subject, and the following description will be confined to a brief outline of its growth, its original extent, its two periods of degeneration, and lastly to its eventual adult representatives.

The mesonephros, developing from the mesoderm of the intermediate cell mass, is first seen in the 13th, 14th, and 15th segments in an embryo of 2·5 mm. greatest length (*Fig.* 86). These segments correspond to the 2nd, 3rd, and 4th thoracic segments. (From now onwards the segments will be

denominated cervical, thoracic, and lumbar—the reader will remember that the first four pairs of primitive segments are taken up in the development of the head.) Growth occurs in both directions, for, in an embryo of 5·3 mm. greatest length, mesonephric tubules have extended to the 6th cervical segment, and in an embryo of 7 mm. the caudal limits of its extension have been reached, i.e., to the 3rd lumbar segment. It will be seen then that mesonephric elements are developed in the 6th cervical to the 3rd lumbar segments both inclusive, making a total of 18 segments. In these segments the development of the tubules is dysmetameric, and several tubules are formed in each segment. Felix estimates that a maximum of 83 tubules are formed in each mesonephros.

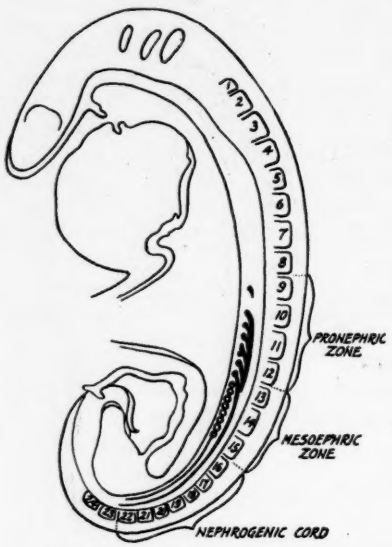


FIG. 86.—Diagram showing the left excretory apparatus of an embryo of 2·5 mm. and 24 pairs of segments. Pronephric elements can be seen in the 9th to 13th segments, mesonephric vesicles in the 13th to 16th, and, caudal to that, the part of the intermediate cell mass which will give rise to the rest of the mesonephros and the metanephros. (*Modified from Felix.*)

The first period of degeneration begins before the caudal extension is complete, for as soon as the cranial tubules are fully developed they begin to degenerate. It therefore starts in the 5·3 mm. stage, and continues until the embryo has reached 21 mm. greatest length. Beginning in the 6th cervical segment, degeneration proceeds in a continuous and regular fashion down to and including the 12th thoracic; 15 segments therefore disappear, and only the three caudal ones persist. In terms of tubules, Felix[7] estimates 57 out of 83 degenerate and should disappear entirely; but a most important fact is emphasized by Zuckerkandl,[15] that remains of these tubules can sometimes be identified long after the normal date of their disappearance. For the purpose of this paper the foregoing facts are of very great importance. The mesonephros in the whole range of its development is lying in the retroperitoneum, and there are 57 tubules which should normally disappear. It is reasonable to suppose that in a certain number of cases one of these may remain as a vestigial structure, and, should it do so, another possible origin of retroperitoneal cysts has been demonstrated (*Figs.* 87 and 88).

The second period of degeneration occurs later, and is concerned with the remaining 26 tubules, all situated in the lumbar region. The upper group, consisting of the 58th to 69th tubules inclusive, form the epigenitalis, and the lower group of the 70th to 83rd tubules, the paragenitalis. The former are intimately concerned with the development of the genital glands, and are of no importance here. For exactly the same reason the paragenitalis tubules in the male need no description; but in the female the various tubular structures formed in and near the broad ligament are all derived from these paragenitalis tubules. The structures referred to are included under the

several names of paroophoron, Kobelt's tubules, etc. Certain retroperitoneal cysts in the pelvis undoubtedly arise in these mesonephric structures.

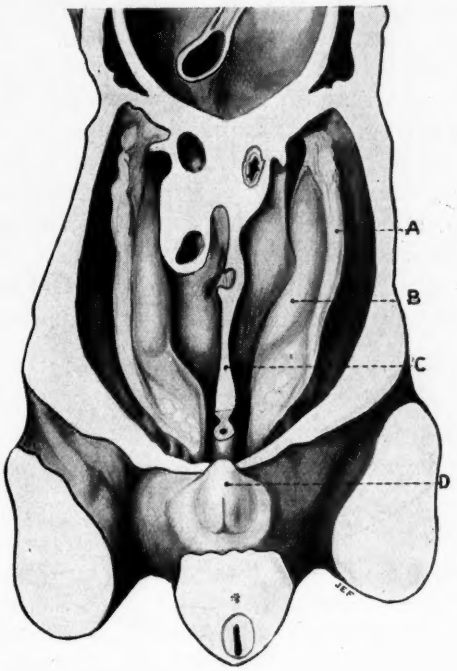


FIG. 87.—Diagram of the structures of the post-abdominal wall and the pericardium of an embryo of 16 mm., showing the ridge formed by the mesonephros on each side. The ridge is already dividing longitudinally into two, to form the genital gland. The extent of the mesonephros will be seen to be from the top of the retroperitoneum right to the pelvis.

A, Mesonephros; B, Genital ridge; C, Median mesentery; D, Genital tubercle. (*Copied by Miss I. C. Mann from a drawing of Prof. J. E. S. Frazer.*)

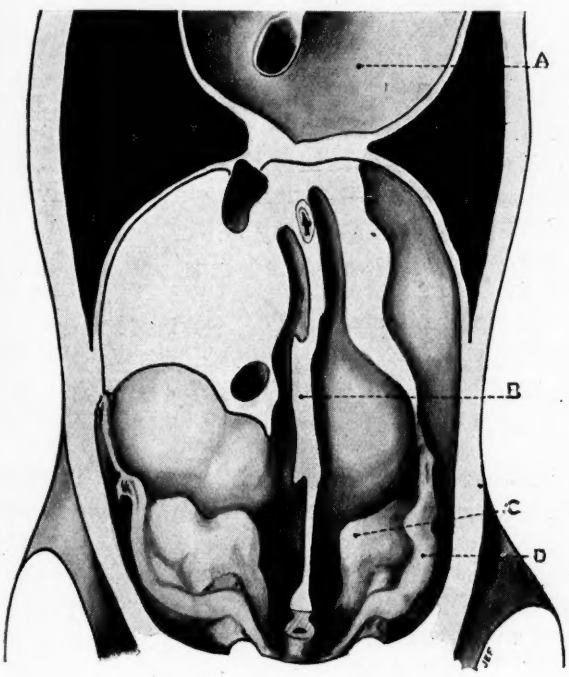


FIG. 88.—Diagram similar to *Fig.* 87 in an embryo of 28 mm. It shows the degeneration of the mesonephros, the marked growth of the suprarenal; and the line of disappearance of the mesonephros is seen to be from the lateral ligament of the liver down to the internal abdominal ring.

A, Pericardium; B, Median mesentery; C, Genital gland; D, Mesonephros. (*Copied by Miss I. C. Mann from a drawing of Prof. J. E. S. Frazer.*)

3. **The Metanephros.**—This arises from the nephrogenic cord in its caudal quarter, and is divided embryologically and physiologically into two parts—the excretory and the efferent. The efferent system develops from the Wolffian duct in the 5th lumbar segment, at the point where it turns horizontally forward to enter the lateral wall of the cloaca. From this origin the ureteric bud, first seen in embryos of between 4·5 and 5·3 mm. greatest length, grows at first dorsally towards the vertebral column, and then, gradually curving, grows cranially behind the mesonephros in the retroperitoneum. This cranial growth continues until it held up by the lateral outgrowths, which, acting as an anchor, prevent a further growth forwards (*Fig.* 89). By the 13-mm. stage, the adult position of the renal pelvis opposite the 2nd lumbar vertebra has been reached. Increase in length of the ureter occurs caudally, for it is in the lumbar region that the body growth principally takes place. The ureteric bud divides into two poles, and these begin growing on their own account; so are the collecting tubules of the first order formed. These again form collecting tubules of the second order, and so on and so on, until there are formed tubules of the 1st to the 12th order and terminal collecting tubules. The final completion of this series occurs during the fifth month.

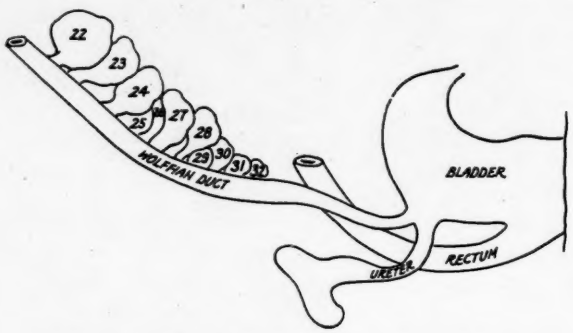


FIG. 89.—The right side of an embryo of 9·5 mm. greatest length, in which the ureteric bud has formed a primitive pelvis, and has divided into its first two tubules. (*After Felix.*)

The excretory system arises in that part of the nephrogenic cord which lies in direct sequence with, and caudal to, the last mesonephric segment. In the human embryo it is quite small, and on the formation of the ureteric bud lies internal to it; but it rapidly grows around the ureteric bud, and provides it with a cap. When the collecting tubules of the 1st order form, the metanephric cap divides, keeping pace with the tubules, thus providing each set with a cap of excretory tissue. And so the process advances with every formation of a new order of collecting tubules, until at last all 12 orders of tubules are formed, each with their own excretory cap. At this stage, so closely packed together are the branches of this ureteric tree, that the contiguous islands of excretory tissue all coalesce, and the first representation of the formed kidney is now obtained. From the excretory caps are formed Bowman's capsules and the uriniferous tubules.

It is clear, therefore, that union must take place between the terminal collecting tubules and the uriniferous tubules before the function of the kidney can be established. There is apparently a union of some tubules in one of the earliest orders; but the view held by Felix is that the final union occurs much later. However accomplished, this union is a most complicated process, and for this reason slight disturbances of development may give rise to quite marked anomalies.

The account here given is the commonly accepted theory as so ably expounded by Felix; but it is not possible to leave the subject without referring to the work done by O. F. Kampmeier[12], who has brought forward an entirely new conception of the development of the kidney. He suggests that, in the metanephric caps surmounting the collecting tubules of the 1st order, uriniferous tubules are developed and unite with the collecting tubule. These uriniferous tubules then undergo cystic degeneration and disappear. With the formation of collecting tubules of the 2nd order, uriniferous tubules of the 2nd order develop and unite with the collecting tubules. Again there occur cystic degeneration and disappearance. And so the process continues up to the final order of tubules. If Kampmeier's account be true, it must be obvious that there are enormous numbers of tubules which are formed only to undergo cystic degeneration and death, and therefore the possibilities of such degenerated areas remaining instead of disappearing completely are very great. It seems probable that the origin of certain cystic diseases of the kidney must be sought much earlier in their developmental history than has been previously thought. As will be explained later, single large cysts of the kidney are much easier of explanation by Kampmeier's work than they were before.

4. **The Wolffian Duct.**—The Wolffian duct is the primary excretory duct of the pronephros and mesonephros. Arising originally by the fusion of the pronephric principal tubules, it is joined later by the similar mesonephric tubules. It terminates in the lateral wall of the cloaca, and, as has been explained, gives origin to the ureter bud. During the degeneration of the pronephros and mesonephros, the duct keeps pace with that process. In the male, it is represented by the ducts of the epididymis and the vas deferens: in the female it survives only as the duct of Gartner.

5. **The Müllerian Duct.**—This duct develops primarily from an invagination of the cœlomic mesothelium into the summit of the urogenital fold in the region of the 2nd and 3rd thoracic segments. It is present in embryos of 10 mm. greatest length, and represents the ostium abdominale. From the blind end of this pouch a caudally directed outgrowth takes places, immediately external to the Wolffian duct, i.e., between it and the cœlomic mesothelium. That is the commonly accepted view, though Professor Frazer suggests that there are grounds for believing that the Müllerian duct is really derived from the Wolffian duct by a process of gradually advancing separation, a state of affairs well recognized in lower forms. The Müllerian duct disappears practically entirely in the male, but is, of course, the main groundwork of the architecture of the female generative organs.

III. THE DEVELOPMENT OF THE PERITONEUM OF THE POSTERIOR ABDOMINAL WALL.

I now pass to the development of the peritoneum of the posterior abdominal wall, and particular emphasis will be laid upon it, because I believe that in anomalies of its formation there exists one of the causes of retroperitoneal cysts. As far as I can gather from my reading of the literature, this origin has not been touched on before. My attention was first called to this

possibility by a suggestion from Professor Frazer, and this part of my paper has resulted from our many discussions of this subject.

It is the peritoneal relations of the large intestine to which I wish to draw attention, and I cannot make my point clear unless I touch briefly on the return of the intestine from the umbilical sac and the rotation of the intestine, which the former so largely influences.

1. **The Return of the Intestine within the Abdominal Cavity.**—It will be seen from *Fig.* 90 that in a 35-mm. embryo the mass of intestines is still in the umbilical sac, which is shown opened, exposing the contents *in situ*. It will be appreciated that the colon lies in the left part of the sac, and enters the abdomen to the left of the proximal loop; and further, it can readily be seen that the colon and its mesocolon can be considered in two parts, viz., the abdominal and umbilical. The abdominal mesocolon stretches from the neck of the sac to the posterior abdominal wall in the mid-line, and therefore acts as a median septum in the upper part of the abdomen. This is a feature of the highest importance.

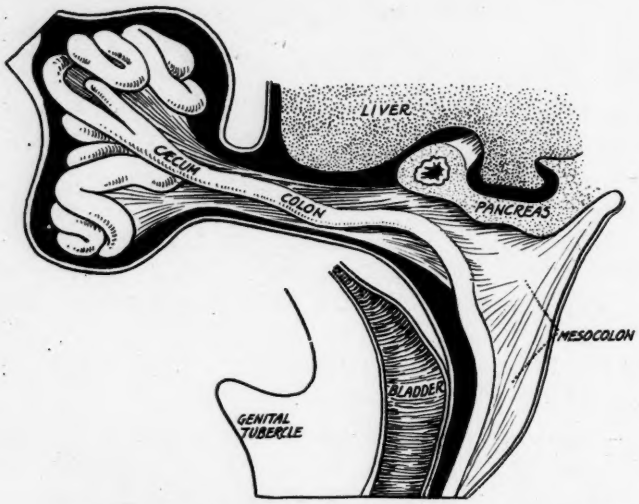
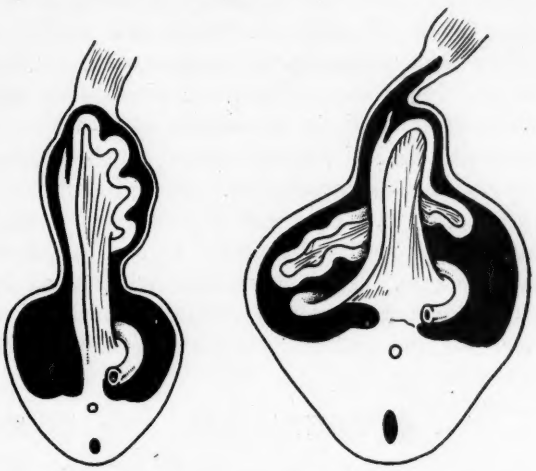


FIG. 90.—Drawing of a section through an embryo of 35 mm. just to the left of the middle line, seen from the left. The umbilical sac is opened and the intestine seen *in situ*. The cæcum and appendix will be seen in the left of the sac, and the returning colon is on the left of the proximal loop. The abdominal colon and its mesocolon are well shown. (*From a reconstruction by Frazer and Robbins.*)

Frazer and Robbins,[8] in their admirably lucid paper on the factors concerned in the rotation of the intestine in man, have developed a reasoned argument to explain the mechanism by which the intestine returns and takes up its eventual adult position. They point out that the return is a rapid—almost instantaneous—process, and is brought about by the changes in relative pressures of the abdominal cavity and amniotic sac. They proceed to show that the return begins with the proximal loop, followed by the next coil, and the next, and so on, until at last only the cæcum remains, and on its return that step in the whole process is complete.

The disposition of the returning loops follows a definite plan, and has far-reaching effects upon the development of the peritoneum of the posterior abdominal wall. If it be recalled that the proximal loop in the neck of the umbilical sac lies to the right of the distal or colic loop (*Fig.* 90), and that the abdominal mesocolon forms a median septum, it follows that the returning loop must necessarily pass to the right of this septum, and will then lie below the right lobe of the liver. As more intestine returns, the mesocolon is displaced dorsally and to the left, and the coils come to lie ventral to it, and

below the cæcum and ascending colon, which are still in the sac. When this part of the gut returns, it will lie above and ventral to the coils of small intestine and below the liver (*Figs.* 91 and 92). It has naturally turned towards the right, thus coming into line with the distal part of the colon. As the coils increase rapidly in length, the cæcum is pressed back until it reaches the dorsal wall, on which it lies, but to which it is not adherent.



FIGS. 91, 92.—Diagrams of abdominal cavity and umbilical sac seen on section from above, to illustrate the mechanism of the laying down of the mesocolon on the posterior abdominal wall (see text). (*After Frazer and Robbins.*)

2. The Method by which the Colon gains its Adult Position: the Mesocolon.—The foregoing description has brought the cæcum and the ascending and descending colon into relationship with the posterior abdominal wall, but they have not yet reached their adult position. This is seen in an embryo of 55 mm. (*see Fig.* 93). It remains to describe how this is brought about. *Fig.* 94 explains diagrammatically the extension of the colon. No. 1 represents the position in a 45-mm. embryo, No. 2 that in a 63-mm., No. 3 that in a 125-mm., No. 4 that in a 160-mm. embryo, and No. 5 that in a full-time fœtus. From this it is evident that the whole colon is elongating; the future splenic flexure is travelling

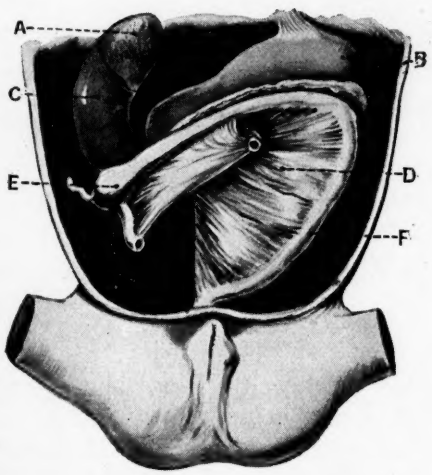


FIG. 93.—Drawing of an embryo of 61 mm. dissected to show the mesocolon. The small intestine has been removed. The cæcum is seen on the posterior abdominal wall, but not adherent, and the descending colon is shown well out towards the flank, but not adherent. It is held up by a glass rod. The mesocolon is well shown, that on the right being derived from the mesentery of the loop, that on the left from the abdominal mesocolon. A, Suprarenal; B, Stomach; C, Kidney; D, Mesocolon; E, Cæcum; F, Descending colon.

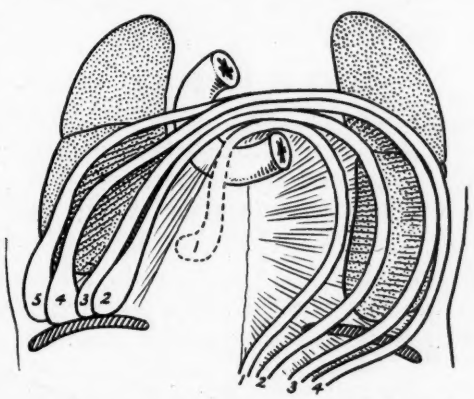


FIG. 94.—A scheme from Frazer and Robbins' paper to illustrate the gradual movement of the colon outwards from the mid-line (see text for description).

upwards and to the left, and the hepatic flexure to the right and less markedly upwards because of the liver; with this there occurs an extension in the area of the mesocolon, and it is to the ascending and descending colon that particular attention will now be drawn. When the ascending and descending colon with their mesocolon are swung back upon the posterior abdominal wall, it is evident that three layers of peritoneum must be in contact, viz., the peritoneum of the posterior abdominal wall and the two layers of the mesocolon. It follows that, for the adult arrangement to be produced, two of these layers must disappear, leaving the gut fixed on the abdominal wall. The two layers to go must be the posterior one and the middle one. The contention here raised is that, should these two layers fail to disappear completely, small islands of peritoneum will remain behind the peritoneum, and that these may act as the *Anlage* of a retroperitoneal cyst.

IV. CLASSIFICATION AND DESCRIPTION OF CYSTS OF VARIOUS ORIGINS.

Having briefly outlined certain embryological processes, I now turn to a description of the several varieties of retroperitoneal cysts, and will therefore suggest a classification of them. It may not be exhaustive, and is assuredly open to criticism; but it does, in my opinion, cover the ground, and, moreover, deals with the subject on an embryologico-anatomical basis, which I believe to be the correct one.

A. **Cysts of urogenital origin**
1. **Pronephric**
2. **Mesonephric**
3. **Metanephric**
4. **Müllerian**

B. **Cysts of mesocolic origin**

C. **Cysts arising in cell inclusions—Teratomatous cysts**

D. **Lymphatic cysts**

E. **Traumatic blood cysts**

F. **Parasitic cysts**

G. **Cysts of developmental origin in fully-formed organs**
1. **The kidney**
2. **The pancreas**

Some of these almost explain themselves, but a short description of them all will be given.

A.—Cysts of Urogenital Origin.

Naked-eye Appearance.—When first exposed and seen *in situ*, they appear as bluish thin-walled cysts and rather flabby, never being tightly distended. When removed they are translucent and lose their bluish tinge. There are no visible vessels in their walls; they have no demonstrable pedicle and no connections—save by areolar tissue—with the surrounding structures. When opened they have a smooth, glistening lining membrane; are single, not multilocular; and contain a clear serous fluid of low specific gravity, in which there is occasionally cholesterin.

Microscopic Appearances.—The wall is thin and consists of a cellular fibrous tissue lined by epithelium, which is usually of a low columnar type, but may be cubical, and rarely is flattened. In one section in my possession the columnar epithelium contains one or two goblet cells, which stain with

muci-carmine. The cells are small, have well-staining nuclei, and a cytoplasm which stains faintly with eosin.

Situation.—From a study of the development of the urogenital system, it is clear that these cysts will occur in an area bounded above by the lateral ligament of the liver, below by the internal inguinal ring, internally by the outer margin of the psoas magnus muscle, and externally by the lateral abdominal wall. A second area lies in the pelvis along the line of the vas deferens in the male and the broad ligament in the female. The majority of the reported cases occur near the kidneys or behind the colon, and near the head or tail of the pancreas.

The question must inevitably arise as to the identification of such conditions, when a retroperitoneal cyst is met with in a patient. Can a cyst be established beyond question to be of urogenital origin? I think not, though their situation and histology are suggestive. The fact remains that there is nothing absolutely conclusive about their histology, and no dogmatic expression of opinion is justified. I hope, however, I may claim that I have demonstrated that there are ample possibilities of remnants of this embryologic system to render such an origin probable; but even if this premise be accepted, it is still difficult to establish from which part of the system any particular cyst has arisen. It can be said, however, that a cyst lying above the plane of the foramen of Winslow is either pronephric or mesonephric in origin, those below that level either mesonephric or metanephric. And when cysts are found near to an unusually small kidney, then there are strong grounds for assuming that the cyst is of metanephric origin. My first case and that reported by Frazier[9] are examples of this type.

On the subject of cysts of the female pelvis, very little doubt need be entertained. Those occurring in or near the broad ligament are well recognized, and have been given various names by gynæcologists. They had much better be designated broad ligament Wolffian cysts, for they are undoubtedly of mesonephric origin.

Fimbrial cysts are, of course, Müllerian.

Case 1 has already been described. *Case* 2 occurred in the practice of my father's partner, Dr. Cowper, of Shanklin, Isle of Wight, to whom I am indebted for the details of the case and the microscopic preparations. As will be seen, the record is not quite complete, for I have had to rely upon a description of the case.

Case 2.—A girl of 15 years had a sudden transient symptomless hæmaturia lasting thirty-six hours, succeeded three months later by an exactly similar attack. Dr. Cowper was then asked to see her, and a swelling was found in the left side of the abdomen, rather high up and partly under cover of the left costal margin. The swelling was soft and apparently cystic, and an exploratory laparotomy was decided upon. A large cyst was found pushing the stomach and transverse colon in front of it, and coming apparently from the back of the abdomen. Considerable difficulty was experienced, but it was traced back to the neighbourhood of the left kidney. Attached to its deepest part were three tubules, each about the size of a normal vas deferens. The cyst and tubules were removed, but unfortunately it was not possible to define the exact connections of these tubules. The wound was closed, a rubber tissue drain being inserted. The patient stood the operation well, and all went well until, on the third day, there was a clear discharge from the wound. The next day this had become more copious, and was soon recognized as urine.

This urinary fistula continued for some weeks, until a left-sided nephrectomy was performed. The wound then healed without difficulty.

The cyst itself was typical in its naked-eye appearance, but the wall contained a thin layer of unstriped muscle fibres. The contents were clear fluid, but were not examined chemically. One tubule was sectioned, and showed the same structure as the cyst wall. Both had a lining of very rudimentary epithelium, which was only present in small areas.

The kidney was described as small, and infantile in type, being markedly lobulated, but no obvious lesion could be found in it. That it had some connection with the cyst seems indisputable, but the exact nature of that connection cannot now be stated. It seems probable that this was some anomaly in development of the excretory system, but beyond that it is not possible to go.

Cases similar to *Case* 1 are reported by Ashhurst,[2] Lapointe,[13] Frazier,[9] Elder,[5] Elter,[6] and others.

Cysts of urogenital origin occur in both sexes, but more commonly in women. They are seen between the ages of 10 and 50, but the decade 15–25 provides most of the cases. The left side of the abdomen is more frequently affected than the right.

B. **Cysts of Mesocolic Origin.**—In general appearance these will resemble the urogenital cysts described above, and are composed of a fibrous wall lined by a delicate flattened epithelium. They are found only in the area between the ascending and descending colon and below the transverse mesocolon. When they are removed they show little to distinguish them, but while still *in situ* one anatomical relationship will decide the question. Mesocolic cysts will lie anterior to the spermatic or ovarian vessels, while urogenital ones will be posterior to them. This is a point worth investigating during an operation on these conditions.

Case 3.—Post-mortem case, male, age 64, death due to heart failure after a preliminary suprapubic cystostomy for enlarged prostate. A small cyst was found lying behind the peritoneum and in close contact with it, to the inner side of the descending colon, and near the spermatic vessels. It consisted of a thin fibrous wall, lined in some places only by a fine, flattened epithelium. (Many of these cysts are reported as having no lining membrane at all, but traces of one can usually be found after prolonged search.) This cyst is either mesocolic or lymphatic in origin.

C. **Cysts arising in Cell Inclusions.**—The teratomatous cyst—commonly known as the dermoid cyst—is found not infrequently in the retroperitoneal tissues. Two of my cases were of this nature, and a third I owe to the courtesy of Dr. Robert Knox and Dr. Harrison Orton. Their structure is well known, being composed of a fairly thick cyst wall, and containing usually an intra-cystic prominence upon which may be found teeth and hair. The cyst is usually filled with sebaceous material and hairs.

Case 4.—Woman, age 62, had vague indefinite pains in the lower part of the abdomen and in the back for several weeks. She had a bad attack of diarrhœa fourteen days before admission. On examination, a rounded swelling was felt in the neighbourhood of the cæcum. Typical 'dermoid' cyst removed from behind the cæcum.

Case 5.—Age 59, with a very similar history to the above. In this case a cyst was found behind the peritoneum near the hepatic flexure. It contained sebaceous material and hairs, and was lined by squamous epithelium.

Case 6.—(Dr. Robert Knox's case). Discovered unsuspected in the course of a barium meal examination. It was found to be attached to the anterior aspect of the head of the pancreas.

The origin of the teratomata has been the subject of many theories and much criticism. No useful purpose would be served by a discussion of such theories here; but retroperitoneal dermoids are among the rarer teratomata, occurring as they do outside the genital system, and it is these extra-genital cases that have discredited several theories that might explain ovarian or testicular tumours, but which could not account for the remainder. There is one theory that has not obtained that prominence to which it is justly entitled, viz., *Felix's strayed genital cell theory*. In the past most embryologists have accepted the view that the genital cells arise in the cœlomic mesothelium of the genital ridge of the urogenital fold; but the modern view suggests that the primary genital cells are of much earlier origin than this, being derived from the segmentation cells. *Fig.* 95 shows two such primary genital cells in the region of the cloaca in an embryo of 2·6 mm. with 13–14 pairs of segments, and *Fig.* 96 shows one in the root of the mesentery in an embryo of 4·7 mm. with 33 pairs of segments. It follows that, in order to reach the *Anlagen* of the genital glands, these cells have some distance to travel. It is doubtful if they all reach their goal, and the possibility of some 'strayed' genital cells must be admitted. These cells are toti-potential cells, and therefore are possible sources of teratomata. The retroperitoneal cases are all found somewhere near the root of the mesentery, and that would appear suggestive, for the root of the mesentery is the commonest place for these genital cells to be found in very young embryos.

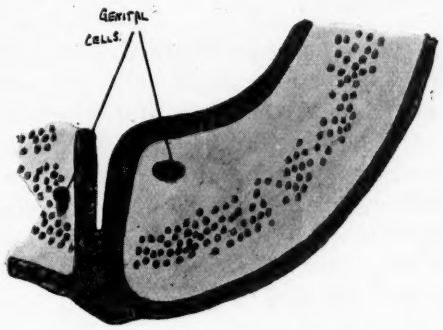


FIG. 95.—The cloacal region of an embryo of 2·5 mm. greatest length. Two multinucleate genital cells are seen near the cloacal membrane. (*After Felix.*)

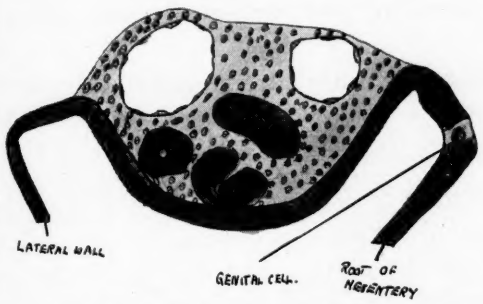


FIG. 96.—Section through the 11th primitive segment of an embryo of 4·7 mm. in length. It passes through the urogenital fold, and shows a primary genital cell in the root of the intestine. (*After Felix.*)

D. **Lymphatic Cysts.**—These fall into two classes: those formed in the lymphatics returning from the intestine, and those arising in the lymphatic field behind the peritoneum and not connected with the intestine. The first group are known as chylous cysts, and have been fully dealt with by many observers. The second class occur as single cysts of varying size, and are exactly analogous in their origin to the single cystic lymphangioma seen in

the neck. Hadley[11] believes them to be due to anomalies in development of the primitive lymph sacs of the abdominal cavity. Gaudier and Gorse[12] report a case of a very large lymphatic cyst in a boy, age 4, which occupied the iliac fossa and spread through the inguinal canal into the scrotum. Small multiple lymphatic cysts are sometimes seen, particularly in the pelvis, and my colleague, Mr. Aleck Bourne, tells me that he has frequently seen them in the course of gynæcological operations, and that he is convinced of their lymphatic origin.

E. **Traumatic Blood Cysts.**—Chardon[3] records a case of a girl, age 14, who had fallen and injured her right side two years previously. Nothing serious was noted at the time, but when first seen by him she was found to have a cystic swelling in the right side of the abdomen. At operation a typical blood cyst was found in the retroperitoneal tissues behind the ascending colon. Such cysts are due to a hæmatoma resulting from an injury. These cases will usually be brought to operation as an emergency; but should they not be large enough to cause sufficiently acute symptoms, the development of a blood cyst is a well-recognized result.

F. **Parasitic Cysts.**—The hydatid cyst stage of the *Tænia echinococcus* is not infrequently seen in the retroperitoneal tissues. It may reach such a situation either by the blood stream, by transcœlomic implantation after the rupture of a cyst in the liver, for example, or by penetrating the intestinal wall at that situation. There is a beautiful specimen in the Royal College of Surgeons Museum in the female pelvis, and another in the Museum of St. Mary's Hospital in the male pelvis. The latter is a good example of the curious symptoms for which these retroperitoneal cysts may be responsible. It was behind the prostate and bladder, and had become impacted in the pelvis. As a result it had pushed the prostate forward, kinking the urethra as it passed through the triangular ligament, and caused chronic urinary obstruction.

G. **Cysts of the Pancreas and Kidneys.**—In my introduction to this paper I emphasized that the term retroperitoneal cysts should be applied only to those cysts lying in the fatty tissue behind the peritoneum, attached to their surroundings by areolar tissue only. I do not propose, therefore, to deal at length with cysts of the pancreas and kidneys; but these few remarks will not come amiss, I think, in this place. With regard to pancreatic cysts, Primrose[14] in 1922 pointed out that the description and the nomenclature of these cysts in and around the pancreas was most confused and unsatisfactory. When true cysts of the pancreas are mixed up with 'pseudo-cysts' and parapancreatic cysts, the ordinary reader is entirely misled. Again, Donoghue[4] in 1906, in reviewing the whole ground, analysed twenty reported cases of pancreatic cysts, and could find no evidence that any one of them was really pancreatic in origin. The neighbourhood of the pancreas is one which is favourable for the location of developmental cysts, and I submit that no cyst should be called pancreatic unless it contains pancreatic tissue in its walls or in its pedicle.

With regard to the kidney, two cystic conditions found therein are of developmental origin. The congenital polycystic kidney is well known, and

needs no description. The earlier remarks upon the development of the metanephros will have made clear the two possible methods of its origin. The single cyst of the kidney is, however, quite a different proposition. The commonly accepted theory of the union of the uriniferous tubules with the later orders of collecting tubules could never explain the existence of a large single cyst which had replaced one quarter or more of the kidney; but Kampmeier's theory makes the origin of such a cyst quite clear, for it is easy to understand how a cystic dilatation of one of the second order of collecting tubules could bring about a single cyst with lack of development of that part of the kidney.

V. DIAGNOSIS.

From the foregoing descriptions it will be readily appreciated that the diagnosis is often extremely difficult, and, with the exception of the traumatic blood cysts and the parasitic cysts, there will be little in the history to help. It is, in fact, the very vagueness of the story, the indefiniteness of the signs, and the absence of symptoms typical of other conditions, e.g., the hydronephrosis, that should raise the suspicion of a retroperitoneal cyst. In *Case* 1 vague symptoms pointed to two systems, the intestinal and the renal, but neither could be really suspected with any confidence. In those cysts which lie in the loin, a pyelogram will be undertaken as a routine, and in this investigation we have a small hope of a diagnosis. Should the photograph show an unusually small pelvis with only two calices, and should there be a cystic and movable swelling in the loin, then I suggest that the diagnosis may be made with some degree of confidence.

Pelvic cysts can be much more readily diagnosed by a thorough bimanual examination, but in the majority of cases the diagnosis will probably be that of an ovarian cyst.

VI. TREATMENT.

These cysts should be removed, access being gained by the most convenient route, through the loin or through the anterior abdominal wall. The loin approach will in many cases give the best exposure, but cysts near the pancreas will demand a laparotomy. The developmental cysts will shell out with the greatest ease. The only one to give trouble will be the parasitic cyst, especially if it is infected. It will rarely be necessary to marsupialize any of them, and for this reason the cysts near the pancreas should be carefully investigated, for all those not truly pancreatic will shell out, and a marsupialized sac will thus be avoided in certain cases.

CONCLUSIONS AND SUMMARY.

I hope I may claim to have presented an accurate classification and a detailed description of these cysts, and a reasonable explanation of their origin. One entirely new possibility has been suggested and supported on embryological grounds. It has been my aim to show how an intimate knowledge of embryology may make clear certain obscure etiological problems. If

it serves to stimulate a closer correlation between the work of the embryologist and the pathologist I shall be satisfied. This has been the principle which has inspired this paper throughout.

My thanks are due to Professor J. E. S. Frazer for his helpful criticism, for permission to use some of his diagrams, and for showing me much of his embryological material. I am also indebted to Mr. W. H. Clayton-Greene, Mr. D. C. L. Fitzwilliams, and Dr. Cowper, for permission to publish cases. To Dr. Robert Knox I owe one of my cases with his X-ray photographs, and to him I offer my sincere thanks. Dr. E. H. Kettle I have to thank for the facilities he has always given me for working in his laboratory, and to him, to Mr. Clayton-Greene, and to Professor Charles A. Pannett I am increasingly indebted for their encouragement and helpful criticism.

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SOME ACTIONS OF RADIATIONS ON LIVING TISSUES.

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(Being the Arris and Gale Lecture delivered at the Royal College of Surgeons of England on February 18, 1924.)

The earliest observations upon the action of X rays on the tissues were made upon X-ray workers who were found to develop a peculiar form of dermatitis as a result of continued exposure to the rays. The phenomena attending X-ray dermatitis are too well known to need recapitulation here; but *Figs.* 97 and 98 may be of interest as showing the development of a malignant neoplasm as a sequel to continued exposure after the patient had received an X-ray burn.

Fig. 97.—This shows a neoplastic ulcer on the finger of an X-ray worker, resulting from prolonged exposure to the rays.

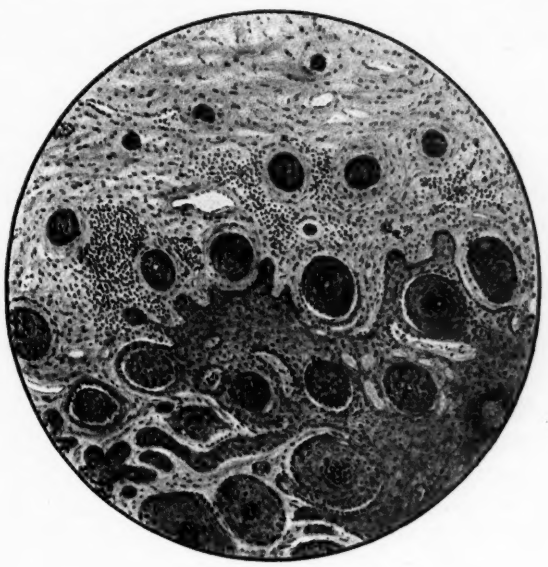

Fig. 98.—Microscopic section of the margin of the ulcer depicted in *Fig.* 97. It shows hyperplasia of the inter-papillary processes and proliferation of the prickle-cell layer. There is a definite round-celled infiltration and some fibrosis.

That radium salts could produce effects upon the skin similar to those caused by exposure to X rays was noted as early as 1900, while in the following year Becquerel accidentally demonstrated the effect on his own person by carrying an insufficiently protected tube of radium bromide in his waistcoat pocket. The glass tube, which measured 15 × 3 mm., was wrapped in paper, enclosed in a little cardboard box, and deposited in M. Becquerel's pocket, where it remained for some hours. A week later an area of redness measuring 6 × 4 cm. made its appearance upon the abdominal wall. The inflammation

progressed, eleven days later the skin disappeared, and an ulcerated surface remained which did not completely heal for a month.

A large amount of experimental work upon animals has been carried out in connection with the action of radium rays upon the skin. The animals employed included pigs, guinea-pigs, and mice, while the amount of radium salt varied from 6 mgrm. of the sulphate to 130 mgrm. of radium-barium bromide. The radium capsules were covered with mica or thin aluminium, and in one case a 'varnish' applicator was used. In all cases there was a latent period between exposure to the rays and the appearance of any visible reaction. As an example of this experimental work we may briefly summarize some researches of Halkin upon the skin of young pigs.[1]

The radium capsule, which contained 130 mgrm. of radium-barium bromide, was closed by an aluminium covering 1 mm. in thickness. This was placed in immediate contact with the skin, secured with adhesive plaster, and allowed to remain for two hours. On the eighth day after exposure, the first visible evidence of reaction was noted as a livid spot disappearing under pressure. The maximum change was seen between the twentieth and the twenty-fourth days. About this time the surface of the irradiated area had a bluish livid tint, with areas of yellow pigmentation and patches of desquamated epidermis. In the centre of the area the inflammatory changes were more marked, and a small dry scab covered an ulcerated surface. The changes subsequently became more definitely reparative in character, and all that was noticeable on the thirty-eighth day was a slightly pigmented diffuse mark with some desquamation.

Another series of pigs was exposed to radium in exactly the same manner and with the same capsule of radium-barium bromide. In this case, however, the exposure was only for one hour. The reaction was longer in appearing—fifteen days—was of less intensity, and disappeared sooner than in the two-hour series.

Radium Dermatitis (*Figs.* 99, 100, 101).—Radium dermatitis, being much less common than the condition produced by X rays, has received small attention in this country, although the Americans have considered the matter in some detail. It is only within recent years that the ultra-violet and chemical rays of the spectrum have been appreciated as the more important agents in the production of many common clinical conditions. Previously erythema solare and the common freckle were attributed to the heat of the sun. It was also noticed that certain cases of lupus erythematosus suggested that light was the determining factor in the site of the eruption. Hydroa æstivale belongs to the same group of diseases. The production of pigmentation by means of the carbon arc in the latest type of treatment in lupus vulgaris is merely another instance of the importance of the rays at the violet end of the spectrum.

Clinically the pictures produced by excessive exposure to the X rays and to radium are indistinguishable. This is to be expected when it is remembered that the γ rays of radium are in juxtaposition in the spectrum with, and overlap, the X rays. The important fact is demonstrated by the following case :—

Mr. —, age 65, has been handling radium salts continuously since 1904. During 1913 he noticed for the first time a little roughness of the hands ; at

the same time he experienced a tingling sensation in the fingers. The war saw a very considerable increase in the amount of material that passed through his hands, with the result that in 1916 his hands became discolored and his nails began to fissure and were very friable. The first appearance of warts was delayed until 1920, since when they have gradually increased in number.

FIG. 99.—Photograph of both hands, showing atrophic pigmented skin with telangiectases and warts. Striation and fissuring of the nails is well marked.

To-day the skin of both hands is atrophic, thin, dry, and wrinkled; there are scattered about numerous small patches of lightish-brown pigmentation. Dilated capillaries form a thin network over the surface. There are present numerous small hyperkeratoses, the largest being on the third digit of the left hand, and its size less than that of a threepenny piece. No ulcers are anywhere present. The nails are all thinned, striated, fissured, and brittle. The nail bed at its free edge is markedly thickened. Great stress has been laid on this phenomenon as being characteristic of radium dermatitis, and indeed it is the only means of distinction between it and X-ray dermatitis.

FIG. 100.—High-power view of the centre of the wart. There is extensive epithelial proliferation, with degeneration and vacuolation of the cells. Early invasion of the corium by the epithelial cells is well seen.

For histological purposes the largest wart was excised under local anæsthesia. The wound healed well. The picture presented under the microscope is that of chronic inflammation, together with very early squamous-cell carcinoma. The stratum corneum is markedly thickened, but most of its cells have been lost over the centre of the wart. The stratum granulosum is not very distinct. The interpapillary processes are prolonged downwards to a marked

extent, as well as showing some branching. There are numerous cell nests, and a few squamous cells are very definitely seen to be invading the corium. The condition is one of early, but yet unmistakable, malignancy. The cells in the centre of the processes are in places definitely degenerate; many others are swollen and show apparent vacuolation around the nuclei; whether this is true vacuolation or œdema of the cells is not clear. Among the prickle cells a few mitotic figures were observed. Even where karyokinesis was not evident, the nuclei varied greatly in size, the larger of them presenting a very active appearance.

The superficial layers of the corium are œdematous, whilst the deeper layers show a definite increase in the white fibrous tissue. In places a slight secondary leucocytic infiltration is present. But far and away the most important feature is the destruction of the elastic tissue; in many places it is absent, whilst when present it is completely disrupted and is seen as short twisted fibrils. This striking result of excessive radiations will be better appreciated when it is realized that the accompanying illustration (*Fig.* 101) portrays the field in which most elastic tissue was observed.

FIG. 101.—A section stained to demonstrate the destruction of the elastic tissue in the corium.

Thus, it is seen that radium and X-ray dermatitis are exactly similar, and indistinguishable both clinically and histologically, except for the subungual hyperkeratosis seen in the former condition.

The process of healing in cases of damage caused to the skin by exposure to radium manifestly depends upon the amount of damage which has been produced. In some cases only the hair follicles and sweat glands are permanently destroyed; in more extreme cases attended with ulceration, the ulcer heals in the ordinary manner with the formation of fibrous tissue.

The Action of the X Rays on the Developing Chick Embryo.—The first experiments upon the effects of exposure of chick embryos to the X rays were those of Gilman and Baetjer[2] in 1904. Here the observers recorded an initial acceleration of development, followed by retardation and the production of abnormal forms. Bordier and Galimard[3] in 1905 obtained inhibition of development as a result of exposure, as also did Gaskell in 1911. In 1922 a series of experiments by Drs. H. A. Colwell,[4] R. J. Gladstone, and myself were carried out at King's College Hospital. The object of these experiments was to ascertain the action of rays of different degrees of 'hardness' upon developing tissues. The chick embryo was selected as the subject of experiment, and

a series of 36 fertilized eggs were subjected daily to irradiation for a period of eight days. These were divided into four series, which received one pastille dose, $\frac{4}{8}$, $\frac{1}{2}$, and $\frac{1}{4}$ of a pastille dose respectively daily. The same series of screens were used in all the experiments; they were aluminium screens of $\frac{1}{2}$ mm., 1 mm., and 2 mm. in thickness.

Our conclusions were that in chick embryos irradiated immediately before incubation and then subjected daily to irradiations for several days, the following results were obtained: The action of the rays was in all cases inhibitory, irradiated embryos being invariably smaller than controls. Within the limit of radiation investigated, the effects seem rather to depend upon the total amount of radiation reaching the embryo than upon its quality or 'hardness'. In the series which received a full pastille dose, 6 out of 9 specimens examined showed no sign of development at all. As regards the susceptibility of individual tissues and structures to these conditions, this was found to be most marked in the surface ectoderm, the central nervous system, and the eye.

Further experiments have yielded results which indicate that exposure of embryos which have been allowed to incubate normally for a period of ninety hours, and which have then been exposed to X rays for three successive days, produces in some cases a certain degree of stimulation as indicated by a slight increase in size. These investigations are still in progress.

The Effects of X Rays on the Skin of the Frog Tadpole.—These experiments were carried out at King's College Hospital, and their object was to ascertain the effects of prolonged irradiation upon the rapidly-growing tissue at different periods after exposure, and also to see in what manner these effects are modified by irradiation in the presence of colloidal silver. In the latter case, the effects produced are due not only to the action of the primary beam, but also to the soft secondary radiations given off from the minute colloidal particles of the metal.

For the purpose of experiment, frog tadpoles were used; these were exposed to the unscreened radiations from a Coolidge tube working at 2 ma. with a 7-in. spark-gap. In most of the experiments the animals were exposed in $1\frac{1}{2}$ in. of water in open glass dishes, the distance of the anticathode of the tube being $6\frac{1}{2}$ in. from the surface of the water. As the tadpoles tended to lie at the bottom of the vessel, it is clear that there must have been a certain amount of 'screening' from the superjacent layer of water. In order to diminish this factor, other specimens were exposed for different periods in about $\frac{1}{2}$ in. of water, which was changed from time to time during the exposure, so as to eliminate as far as possible any heating effects. The distance of the anticathode from the surface of the water was, as before, $6\frac{1}{2}$ in. In a further series a small amount (0·04 per cent) of protargol was added to the water containing the tadpoles; in these cases the irradiation was carried out in dishes containing $1\frac{1}{2}$ in. of protargol mixture, the distance of the anticathode being again $6\frac{1}{2}$ in. Seven series of experiments were carried out, and histological examination of the skin was performed.

In the normal tadpole skin the epidermis consists of only two layers of cells (*Fig.* 102). Of these, the superficial layer is formed of somewhat flattened cells with more or less oval nuclei, while in the deep layer the cells tend to

become polygonal in outline and the nuclei roughly correspond to the shape of the cell. The pigment cells lie in the corium in close apposition to the subjacent muscle bundles.

The conclusions drawn from these experiments were as follows: In the specimens irradiated immediately after death, very slight changes were noted. Prolonged irradiation within certain limits causes the characteristic changes to appear more quickly; for instance, a specimen killed immediately after one and a half hours' irradiation showed only some increase in the size of the nuclei of the superficial epidermal layer, together with evidences of increased activity; while specimens which had received two hours' irradiation, and which were killed immediately afterwards, showed slight but definite hyperplasia. Irradiation in the presence of colloidal silver causes much more rapid and profound changes. These were of a markedly stimulative character, within the limits of time after irradiation in which observations were made. (*Figs.* 103, 104.)

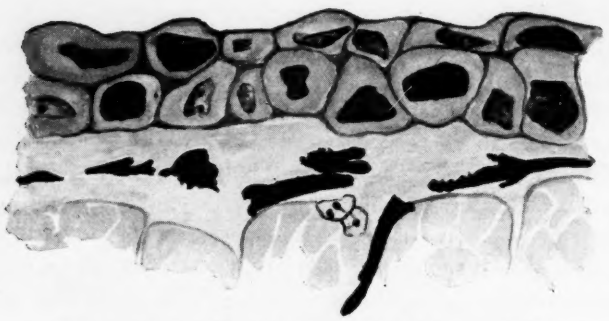

FIG. 102.—Section of normal skin of frog tadpole.

A further series of experiments is being carried out on the skin of frogs and other cold-blooded animals, and will be published in due course.

Action on Blood-vessels.—The endothelial lining of the smaller blood-vessels is remarkably sensitive to radiations, the cells becoming swollen, vacuolated, and degenerated, with a tendency to irregular proliferation into the lumen of the vessel. At the same time the vessel wall is infiltrated by leucocytes. From these facts it is clear that exposure to radiations tends to destruction of the blood-vessels, and this explains the clinical use of radium in the treatment of nævi. It shows, moreover, the necessity for care in the clinical use of radium in situations where hæmorrhage cannot be readily controlled and there is reason to suspect the presence of pre-existing degenerative vascular changes.

Exposure to X rays similarly gives rise to degenerative changes in the blood-vessels, and indeed so marked are the changes set up by X rays and radium that they have been regarded as the immediate cause of X-ray and radium burns. Undoubtedly, interference of any kind with the vascular supply to a part must have a greater or less effect in determining the course of any local pathological processes. Vascular changes, however, cannot account for the whole of the phenomenon, and in any case do not afford an explanation of how the vascular endothelium itself comes to be injured.

The changes in the lining cells of the blood-vessels do not occur immediately after exposure to the radiations, but a more or less variable latent period elapses between exposure and its obvious results.

Effects on the Blood.—The action of X rays and the γ rays of radium upon the blood has recently attracted a good deal of attention, as it has

been held responsible for cases of severe—and in some instances fatal—anæmia. These occurred among X-ray and radium workers who carried out their duties under conditions of insufficient protection. With the recent developments of prolonged and intensive X-ray therapy the matter is also obviously

FIG. 103.—Section across tail of tadpole which died 27½ hours after irradiation. Showing hyperplasia and invasion of corium by epithelial cells.

FIG. 104.—Section across tail of tadpole killed 48 hours after irradiation in protargol. General hyperplasia of epithelium is seen.

one of considerable importance, and accurate blood-counts are now a matter of routine procedure in the case both of workers and of patients undergoing treatment. A very large amount of work has been done upon the subject, which it is impossible to discuss here in full detail. The outstanding features

of exposure to the radiations are a marked diminution in the number of lymphocytes, together with a reduction in the number of red cells. In the earliest stages there may be a transient increase in both types of cell. Lymphocytes seem to be especially sensitive to radiations, exposures for quite short periods causing a marked diminution in the lymphocyte count. Polymorphonuclear leucocytes are also diminished in number, but not to the same extent as the lymphocytes. Blood-platelets as a consequence of exposure show a rapid diminution in numbers, followed by a rapid recovery.

As regards the action of radiations upon blood *in vitro*, exposure to radium emanation produces hæmolysis, with the formation of methæmoglobin, the α particles taking by far the largest part in the production of the phenomenon, and they are also destructive to the opsonic power of the serum and to the hæmolytic complement. Exposure to X rays has not been found to interfere with the action of immune sera, nor with that of the hæmolytic complement. Further experimental work, however, is necessary upon the question of the action of radiations upon immune sera. Hæmolytic complement is notoriously unstable, but exposure of samples for two hours to X rays of moderate hardness was found to be without effect.

Action on the Intestines.—The mucous membrane of the intestine is extremely sensitive both to X rays and to the γ radiations from radium, a fact which must be borne in mind from the point of view of the protection of the X-ray worker and of the patient when radiations are being used for the treatment of abdominal conditions. The earliest effect of exposure is the production of an inflammatory condition associated with diarrhœa and, if the dose of rays has been sufficient, the passage of blood-stained mucus. More prolonged exposures lead to destruction of the lining epithelium of the gut, with shrivelling and atrophy of the subjacent tissue. The occurrence of diarrhœa, then, in the case of persons working with X rays or in that of patients undergoing X-ray treatment in the abdominal region, should always receive attention when there is no other obvious cause for its occurrence.

CLINICAL INVESTIGATIONS.

The clinical material investigated was as follows: (1) *Carcinoma of the breast*, 25 cases; (2) *Rodent ulcer*, 58; (3) *Lymphosarcoma of neck*, 4; (4) *Sarcoma of femur*, 3; (5) *Carcinoma of lip*, 2; (6) *Carcinoma of thyroid*, 1; (7) *Carcinoma of mouth*, 4; (8) *Carcinoma of cervix uteri*, 3.

1. **Carcinoma of the Breast.**—The cases of carcinoma of the breast had had a complete amputation of the breast performed previously to the X-ray or radium treatment. No pre-operation treatment by irradiation was given, for the following reasons: the skin under such conditions heals badly, the risk of sepsis is increased, and the tissues are more congested, so that oozing is often considerable. Of the 25 cases, 15 received post-operative irradiation from X rays, this treatment only being given when there were signs of recurrence. All these cases died, the average period being three years from date of operation. Ten cases received immediate radium irradiation at the time of the operation, and subsequent X-ray treatment. Of these, 2 died from secondary manifestations after five and six years respectively. The remaining 8 are alive after an average of six years, although 3 have signs of internal metastases.

The outstanding fact in this series is that no local recurrences have been observed in the cases treated with radium at the time of the operation.

Case 6 in this series was of interest in showing the effect of radiations on the blood-count.

Case 6.—Mrs. S. B., age 50, came under observation in May, 1921, with a lump in the upper and outer quadrant of the left breast. Patient stated she had noticed a lump for six months. The tumour was not attached to the skin or deep fascia. There were no palpable glands in the axilla. Radical removal of the breast, together with both pectoral muscles, axillary fat, and glands, was performed at the end of May. The wound healed well. The tumour was a spheroidal-celled carcinoma. When the patient was seen again early in September, 1921, there was a small recurrent nodule in the scar. It was decided to give X-ray treatment and to see what effect this had on the blood-count. A full pastille dose was given to four areas of the thorax through a 4-mm. aluminium filter, and a blood-count was taken again immediately after the X-ray treatment, and again on the two following days.

Blood-count before X-ray Treatment	After X-ray Treatment		
	Sept. 20, 1921	Sept. 20, 1921	Sept. 21, 1921	Sept. 22, 1921
Red blood-corpuscles, per c.mm.	6,148,000	6,000,100	6,100,000	6,384,000
Total leucocytes, per c.mm.	12,000	12,800	13,000	10,600
Polynuclears ..	68·0 per cent	72·4 per cent	74·4 per cent	70·3 per cent
Lymphocytes ..	29·4 ,,	26·0 ,,	24·0 ,,	27·6 ,,
Eosinophils ..	7·0 ,,	1·6 ,,	1·6 ,,	2·1 ,,

A few days afterwards, on Sept. 27, a blood-count was taken and the patient submitted to a pseudo-dose of X rays, the blood-count was taken, the patient was given a full pastille dose to four areas on the left side of the thorax, and the count taken again. This was tried in order to see if the pseudo X rays had any effects on the leucocyte-count. It was found that no difference could be made out. The results were as follows :—

Blood-count before Pseudo X Rays		After same	After X Rays
Red blood-corpuscles ..	5,936,000		
Total leucocytes ..	10,400	10,800	9,000
Polynuclears	74·2 per cent	72·6 per cent	73·3 per cent
Lymphocytes	24·7 ,,	24·8 ,,	26·3 ,,
Eosinophils	21·0 ,,	2·4 ,,	0·5 ,,

Again, on Oct. 5, 1921, a blood-count was performed before and after the same dose of X rays.

Before X Rays		After X Rays
Red blood-corpuscles ..	4,368,000	
Total leucocytes ..	11,500	10,400
Lymphocytes	27·6 per cent	32·7 per cent
Basophils	0·1 ,,	0·3 ,,
Eosinophils	1·2 ,,	1·2 ,,
Polynuclears	71·1 ,,	65·8 ,,

At first X-ray treatment seems to have a stimulating effect on the production of leucocytes, and later on its action is inhibitory, so that it is necessary when giving deep X-ray therapy to have a blood examination performed from time to time.

In this case radium treatment was substituted in November, 1921, 60 mgrm. filtered through 2 mm. of lead being applied to the recurrent nodule for four hours each month. The nodule disappeared, but the patient gradually became more breathless in February, 1922, and died in the following May. A skiagram demonstrated large secondary deposits in the thorax. No post-mortem examination was permitted.

2. **Rodent Ulcer.**—In the treatment of the earlier cases of rodent ulcer, large doses of radium were used in combination with lead filters; very poor results were obtained. The ulcer increased in size, and in several cases excision was eventually performed. One of the most hopeful methods of application of radium appears to be that of repeated small doses daily for a period of seven to fourteen days, followed by a week or fortnight's rest, when the course of treatment is resumed. In these cases no screen was used beyond the platinum containers in which the radium was placed, which was separated

FIG. 105.—Photograph showing position of rodent ulcer before radium treatment.

FIG. 106.—Photograph showing condition of rodent ulcer after fifteen months' radium treatment.

from the diseased surface merely by a layer of guttapercha or lint, thereby allowing the passage not only of the softer γ radiations, but also some of the hard β rays which appear to play an important part in the process of treatment.

Case 2 in this series is of interest because histological examination was carried out before and after radium treatment. It may be laid down as a general rule that if a rodent ulcer does not respond to radium or X-ray treatment after three months, it should be excised.

Case 2 (*Figs.* 105–109).—William P., age 66, first came under observation in September, 1920, complaining of a small ulcer the size of a shilling situated in the

right temporal region 2 in. behind and 3 in. above the external canthus (*Fig.* 105). This ulcer began in October, 1919, as a small pimple which slowly grew larger and broke down and was treated by different kinds of ointments which had no effect. A small piece of the edge of the ulcer was removed, and microscopically it proved to be a rodent ulcer (*Fig.* 108). Radium treatment was tried for fourteen months;

FIG. 107.—Photograph one month after excision and skin-grafting.

FIG. 108.—Section of edge of rodent ulcer excised before treatment.

FIG. 109.—Section taken after excision of rodent ulcer, showing marked fibrosis as the only change consequent on radium treatment.

60 mgrm. of radium filtered through 2 mm. of platinum were applied to the ulcer every two weeks until December, 1921. As no improvement took place, the ulcer was completely excised and the bare area skin-grafted. The microscopical appearance of the ulcer after removal revealed the fact that a very definite fibrosis had taken place (*Fig.* 109).

3. **Lymphosarcoma of Neck.**—The four cases of lymphosarcoma all responded well locally to radium irradiation at first, but death occurred in each case owing to widely disseminated and deeply-seated metastases.

Case 2 (*Figs.* 110–114).—George W., age 66, came under observation in April, 1922, with a large tumour on the left side of his neck (*Fig.* 110). He first noticed a small lump behind his ear in February, 1922, which soon spread to the whole of

FIG. 110.—Photograph of patient with lymphosarcoma before radium treatment.

FIG. 111.—Photograph showing condition of patient five days after the insertion of 200 mgrm. of radium.

FIG. 112.—Photograph of same patient taken two months after *Fig.* 111.

the side of his neck. At the beginning of May, 1922, the swelling was so large that it compressed the trachea, and a tracheotomy had to be performed on May 10. Radium, 200 mgrm., filtered through 2 mm. of platinum, was inserted deeply into the tumour for eighteen hours on May 15. A small portion of the growth was removed for microscopical examination; the tumour proved to be a lymphosarcoma (*Fig.* 113). The tumour commenced to disappear on May 17, and had

become very much smaller by the 18th, and on May 20 a photograph was taken (*Fig.* 111); the tumour had almost completely disappeared. However, in July growth became palpable on the left side of the neck again, and 100 mgrm. of radium were inserted into the neck for twelve hours; in August, the same quantity of radium

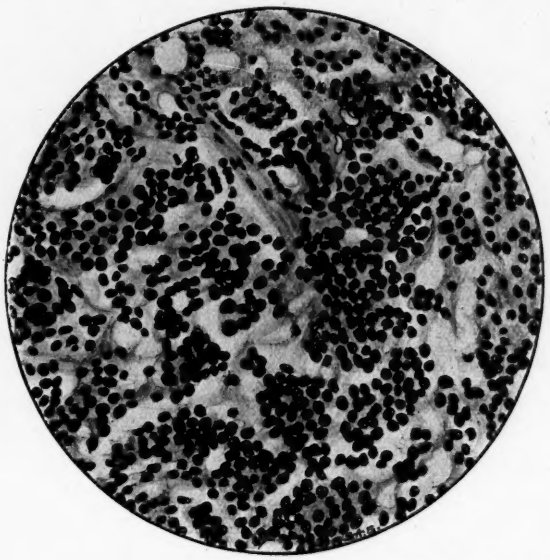

FIG. 113.—Section of lymphosarcoma from portion excised before commencement of radium treatment.

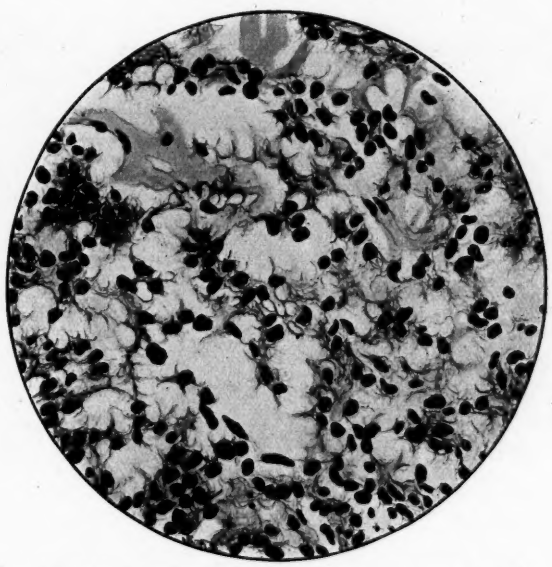

FIG. 114.—Section of growth removed post mortem six months after commencement of radium treatment: showing some degree of degeneration and slight fibrosis.

was again inserted for the same period. The growth had progressed (*Fig.* 112), and in September appeared on the right side of the neck. Radium was again applied, and a small piece of growth removed to ascertain what changes the radium had caused. *Fig.* 114 is a microscope drawing of the tumour. The tumour grew steadily on both sides of the neck, and the patient died on Nov. 3, 1922.

4. **Sarcoma of Femur.**—The three cases of periosteal sarcoma of the femur were inoperable when they came under treatment; in each case secondary deposits were present in the lungs. The size of the primary growth diminished as a result of local insertion of radium combined with X-ray therapy. Death in all cases was due to pulmonary metastases.

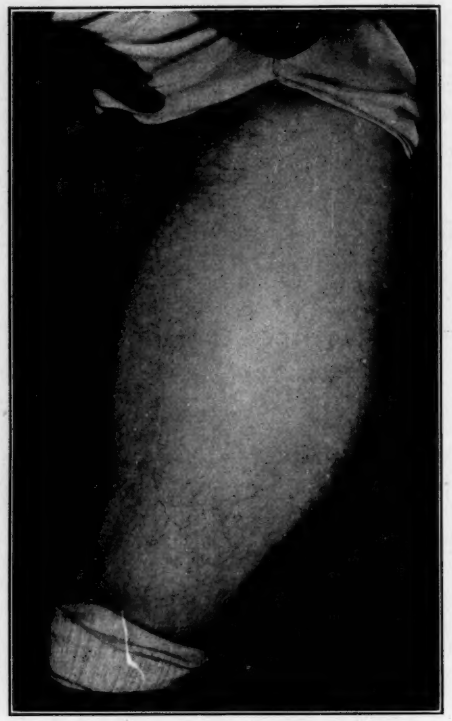

FIG. 115.—Photograph of periosteal sarcoma of femur before radium application.

Case 1 (*Figs.* 115–118).—William L., age 26, married, two children, was admitted to hospital on March 16, 1921, complaining of a tumour in the left thigh. He gave the following history: In August, 1915, while a soldier serving in France, he received a blow on the left thigh from a clod of earth due to the bursting of a shell. He was invalided home twelve months later with a wasted leg. He was admitted to several Army hospitals during the following year, and was finally discharged from the Army in September, 1917, with a pension. In the spring of 1918 he first noticed that his leg was swelling; this gradually increased till March, 1921, when patient, who had been working as a fitter's mate, had to give up work and was admitted to hospital. On examination a firm hard swelling of the left thigh was discovered. Skin not discoloured; no solution of continuity; skin not adherent except for a small area posteriorly. The tumour was fixed to the femur. No egg-shell crackling. Slightly tender to touch. Knee fixed in slight flexion. Liver not palpable. Spleen not felt. No glands. Some dullness in both lungs behind, alongside vertebræ. Secondary deposits confirmed by X rays.

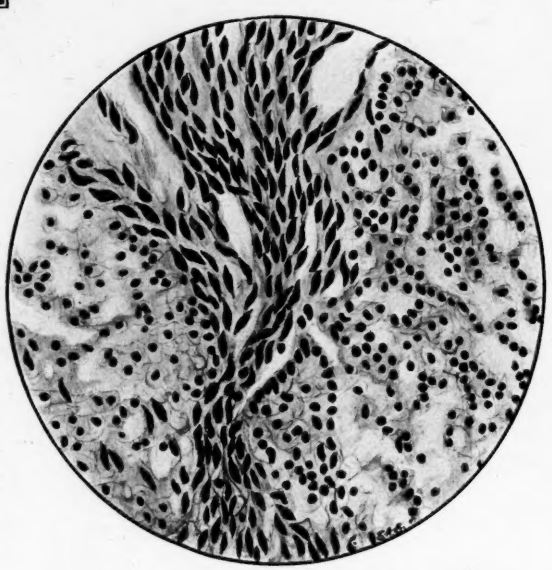

FIG. 116.—Section of periosteal sarcoma of femur before treatment.

OPERATION, March 17, 1921.—A small incision was made in the anterolateral aspect of left thigh over the most prominent part of the tumour. A small piece of the tumour was removed. Macroscopically the tumour looked malignant, and there was no capsule over it. Through the incision 60 mgrm. of radium were inserted for twenty-four hours. The tumour proved on microscopica examination to be a spindle-celled sarcoma (*Fig.* 116). On March 25 a quantity of

radium emanation equal to 100 mgrm. of radium was inserted into the thigh for forty-eight hours. A blood-count was performed on April 9 :—

Red blood-corpuscles	6,320,000 per c.mm. (126·4 per cent)	Polynuclear leucocytes ..	80·4 per cent
Hæmoglobin	98 ,,	Eosinophils	3·3 ,,
Colour index ..	0·77	Lymphocytes	15·6 ,,
		Mast-cells	0·7 ,,

On May 12, 1921, 60 mgrm. of radium with a 1-mm. filter of lead were inserted into a secondary growth in the right lung. The 7th rib was resected and the lung exposed under intratracheal ether anæsthesia. The radium was removed after forty-eight hours.

On May 19, 60 mgrm. of radium with a 1-mm. filter of lead were again inserted into the left thigh for forty-eight hours. The thigh measurement had gone down from 28 in. to 25 in., and patient had gained one stone in weight. Blood-count, May 27, 1921 :—

Red blood-corpuscles	4,068,000 per c.mm.	Polynuclear leucocytes ..	76·8 per cent
White blood-corpuscles	5,600 ,,	Eosinophils	5·2 ,,
Hæmoglobin	60 per cent	Lymphocytes	13·2 ,,
		Mast-cells	3·8 ,,

On June 3, 60 mgrm. of radium with a 1-mm. filter of lead were inserted into the left thigh for forty-eight hours, and again, on June 18, 60 mgrm. of radium with a 1-mm. filter of lead were inserted into the right thigh for forty-eight hours. On July 9, 60 mgrm. of radium with a 1-mm. filter of lead were inserted into a secondary deposit in the left lung under intratracheal anæsthesia, a portion of the 7th rib having been resected. The radium was removed after forty-eight hours. The patient began to lose weight and to go down-hill rapidly after the middle of July, and died on Aug. 1, 1921.

Post-mortem Examination.—Was performed on Aug. 2. The left thigh was amputated and sectioned (*see Figs.* 117, 118). It was a periosteal sarcoma of the spindle-celled variety. There were no growths in the liver or any other abdominal organs. The growths in both lungs were considerably smaller than at operation. There were some mediastinal glands affected with growth.

Fig. 117.—Photograph of femur and growth removed post mortem.

This man received during his stay in hospital the following X-ray treatment :—

March 19 : X-ray treatment to thigh—9 ports of entry 2 in. square ; 6-mm. filter of aluminium ; one full pastille dose to each area ; 62 pastille doses given to thigh between March 19 and May 10.

March 22 : Chest divided into 16 areas 2 in. square ; 6-mm. filter ; full pastille dose to each area ; two areas each day ; 88 pastille doses given to chest between March 22 and July 17.

5. **Carcinoma of Lip.**—The two cases of carcinoma of the lip were inoperable on account of secondary deposits in the glands of the neck which infiltrated deeper structures. Each case was remarkably unresponsive to radium treatment ; the needles of radium were buried in the growth in the usual manner.

6. **Carcinoma of Thyroid.**—The case of carcinoma of the thyroid, although large doses of radium were inserted into the growth on several occasions, did not seem to be at all influenced, but the tumour gradually grew and caused the death of the patient within a year of the diagnosis being made.

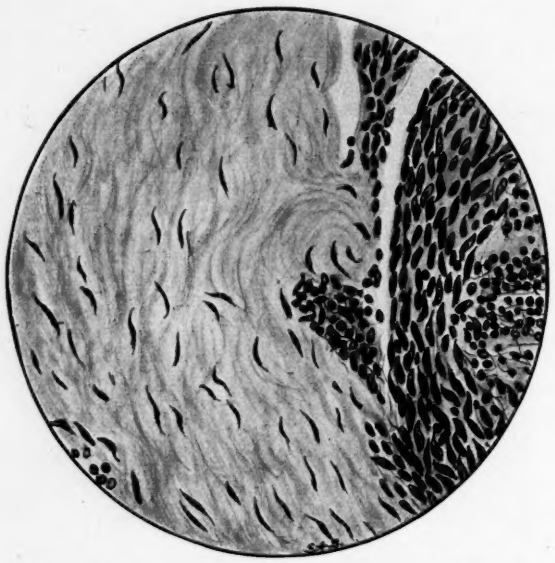

FIG. 118.—Section of growth showing marked fibrosis only after radium treatment.

7. **Carcinoma of Mouth.**—The four cases of inoperable carcinoma of the floor of the mouth were quite unresponsive to radium treatment.

8. **Carcinoma of Cervix Uteri.**—Of the three cases of carcinoma of the cervix, two died within nine months of the first insertion of radium ; whereas the other patient, though considered inoperable at the time radium was inserted, was operated upon subsequently, and is still alive eighteen months after hysterectomy. The notes of this case are given below :—

Mrs. Ada G., age 58, came under observation in July, 1922, complaining of continuous slight hæmorrhage per vaginam. On examination the cervix was ulcerated and was fixed in position to surrounding structures. A diagnosis of inoperable carcinoma of the cervix was made. A small piece of tissue was removed from the cervix, and was found on microscopical examination to be malignant. Radium, 125 mgrm., with a 2-mm. platinum screen, were inserted into cervix for twenty-six hours. Two months later, on Sept. 15, patient was again examined under an anæsthetic. The cervix was now nearly flush with the vaginal vault and looked healthy. There was no sign of ulceration. In the right fornix only slight thickening could be felt ; whereas at the previous examination the pelvic cellular tissue appeared to be extremely involved and fixing the uterus, now the uterus was mobile in every direction. On Sept. 28, 1922, Wertheim's hysterectomy was performed ; the operation was quite easy.

On examination of the parts removed, the cervical canal presented what appeared to be a typical endocervical carcinomatous ulcer. This part was examined by the pathologist, who reported as follows : " Very little epithelium appears in any of the section ; such as there is shows no definite evidence of malignancy.

There are marked necrotic changes, hyaline degeneration, and fibrosis of the muscular coat."

The patient recovered well from the operation, and has put on half a stone in weight since leaving hospital.

CONCLUSIONS.

As regards the mode of action of radiations upon living tissues, various views have from time to time been put forward, such as that the radiations decomposed the lecithin present in the tissue cells, and that its disintegration products acted in an ingenious manner. As a matter of fact this action upon lecithin has not been substantiated by subsequent research.

Another view is that of specific activation of intracellular enzymes. Here, again, most recent investigations fail to demonstrate any such action, and our experiments at King's College Hospital upon the oxidases laccase and tyrosinase fail to show any effect as to sequel to irradiation.

Probably no one theory can explain all the phenomena; but what does seem clearly established is that X rays and the γ radiations from radium have a marked effect upon certain classes of colloids, among which are proteins and starch. Proteins undergo a marked diminution in viscosity, and are more easily precipitable after a radiation than before. In the case of starch, as shown by Colwell and Russ[6] in 1912, this undergoes at any rate a partial change into soluble starch and dextrin.

It seems not improbable that certainly one of the effects of radiation is disturbance of the colloidal equilibrium of the cells, with consequent devitalization. If not carried too far the cell may recover, but if certain limits be exceeded the damage is irreparable, and the intracellular enzymes may then come into play, their action being of a destructive character upon the devitalized cell protoplasm.

The author wishes to acknowledge the kindly interest and assistance given him by his surgical colleagues, and by Dr. H. A. Colwell, Assistant Radiologist at King's College Hospital.

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THE SURGICAL TREATMENT OF OSTEO-ARTHRITIS.

(Being the Hunterian Lecture delivered at the Royal College of Surgeons of England on February 6, 1924.)

By C. MAX PAGE, London.

The chronic joint change recognized in England as osteo-arthritis, and on the Continent as arthritis deformans, is so general in its incidence that its milder forms may almost be regarded as a degenerative process associated with senescence. In certain cases, however, it assumes the character of a destructive pathological process, and may progress to such a degree as to produce serious disability, not only from pain, but on account of deformity secondary to absorption of bone. Moreover, the condition is by no means confined to those past middle age, and when it occurs early in life it seems to run an unusually active course.

The gross anatomy of the joint changes in osteo-arthritis has for long been clearly recognized, and industrious research has been carried out with a view to determining the cause of the condition. It must be admitted that though it has been demonstrated that the joint changes classified as osteo-arthritic may be initiated by several different factors, its etiology still remains obscure. The literature on the subject has become enriched with a confusing nomenclature which has developed as a result of the attempt to classify the various joint changes observed, generally on an anatomical basis. This aspect of the subject was very thoroughly reviewed here last year by Mr. Timbrell Fisher;[1] and at a discussion held at the Royal Society of Medicine[2] a few months later, what may be termed the medical side of the matter was fully debated.

I propose to devote my attention to a consideration of the treatment of cases in which the changes have so far progressed as to be beyond satisfactory relief by medical means. I shall simplify the subject further by omitting reference to conservative surgical methods, and shall confine myself strictly to a detailed consideration of the limited group of cases in which operative procedures can be held justifiable with a view to effecting a radical cure of the condition.

I do not wish to suggest that the more scientific, or even the empirical, procedures which have been applied to check the advance of the condition should be neglected as useless. There are two factors which are generally accepted as responsible for the progression, if not for the initiation, of this destructive process in a joint; they are (1) the presence of a chronic infective focus in some part of the body, and (2) strain or injury of the affected joint. Accepting these etiological causes, treatment directed to their elimination is a natural sequence. It is clear that the removal of any septic focus discovered in the body should not only be part of the treatment in early cases, but should receive equal attention in the more advanced instances in which operation is

contemplated. Rest of the joint involved is definitely suggested when there is pain.

How far the continuation of rest should be pursued with a view to obtaining an approximate cure by stabilization of the joint is an important question to decide, but one which it is difficult to answer. It is sometimes stated that rest and immobilization of an osteo-arthritic joint leads to its ankylosis. From my observation I doubt if a complete bony ankylosis ever results from the osteo-arthritic process unless a definitely inflammatory reaction is added to the ordinary picture. None the less, stability may be obtained by conservative treatment in an osteo-arthritic joint, at any rate sufficient to prevent the progressive absorption of bone, and to reduce the pain to an endurable degree. Once a joint has been denuded of its articular cartilage, progressive absorption will inevitably continue if any considerable range of movement is retained, and if it bears continuous weight. This point must be borne in mind when the selection of the type of operation best suited to the relief of the condition is made.

THE SELECTION OF CASES SUITED TO OPERATIVE TREATMENT.

The primary indications for recourse to radical operation in an osteo-arthritic joint can, I think, be clearly defined as two in number, viz., (1) persistent pain, and (2) progressive deformity in relation to the joint affected. These indications hold good whatever anatomical form the disease assumes, and whether the principal causative factor appears to be trauma, bacterial infection, or toxic absorption. Operation will not usually be undertaken in the presence of evidence of active infection. In young people it may be employed to cut short the uncertain period (always a matter of years) in which stabilization of the joint may occur under non-operative treatment.

In practice the selection of cases for operation will be influenced by the number of joints involved, and the life expectation of the patient. In those cases in which one joint alone is seriously affected, and when there is no suggestion of a general infective process, the decision to operate is a straightforward one. When, on the other hand, the disease is polyarticular in its distribution, operation will only be undertaken to relieve intolerable pain, or to correct disabling deformity after the infective process has become quiescent.

Operations for intercurrent complications of an osteo-arthritic process in a joint, such as the removal of hypertrophic villi or loose bodies, are often resorted to, but they hardly come within the scope of this paper.

The procedures which have been put forward in order to deal radically with osteo-arthritic joints may be roughly classified under three headings, viz.: (1) *Excision of the joint*; (2) *Arthroplasty*; (3) *Erasion of the joint*; (4) *Synovectomy*. The aim of these operations in regard to the final function of the articulation varies considerably.

1. **Excision of the Joint.**—This is the oldest established procedure in the surgery of this condition.[3, 4, 5] Its primary aim is to relieve pain by the removal of the diseased joint surfaces. The functional result expected in the

cases of hip, elbow, wrist, and metatarsal phalangeal joint of the toe is a pseudo-arthrosis. In the knee an arthrodesis in a good position is aimed at.

2. **Arthroplasty.**—The modern formal arthroplastic operation has not had an extensive trial in the treatment of osteo-arthritis, though it is favoured by some in the cases of the great-toe-joint. The operation is generally held to be an undesirable one for this condition, on account of the presumption that the new joint formed will undergo the same pathological changes as were responsible for the primary condition. Though there is evidence that this attitude is a reasonable one in the case of a weight-bearing joint, I do not think it need be adopted in respect of those articulations in which movement is only called for occasionally.

3. **Erasion.**—Erasion of a joint consists in removing the remaining articular cartilage and the underlying or exposed sclerosed bone, the general bony formation of the joint surfaces being retained. The final aim of this operation is generally to produce an arthrodesis, or at any rate fibrous ankylosis of the joint in a good position. In practice it will be found, as is shown in *Table I*, that in a fair number of cases this operation may leave a joint with quite a good range of movement.

4. **Synovectomy.**—This is essentially a conservative operation, which can only be expected to be successful in those cases in which little or no change has occurred in the articular cartilage; and it must therefore be undertaken at an early stage of the case. A radical synovectomy appears to have been first carried out by Müller[6] in 1894. He based it on the hypothesis that the destructive process in an osteo-arthritic joint was initiated in the synovial membrane. Few operations of this character have been recorded, and so the evidence of the truth of the theory is lacking. The class of case which appears to be satisfactorily dealt with by this means is that termed lipoma arborescens or hypertrophic villous synovitis. The condition is most commonly seen in the knee-joint, and from an examination of specimens the disease appears to be primarily synovial, gross deterioration in the articular cartilage only occurring in the later stage of the process.

The decision as to which of these operations should be employed, and also the nature of the after-treatment, varies considerably in respect of different joints; and I will now give some consideration to the more important individual instances.

THE LOWER EXTREMITY.

The Hip-joint.—The pathological condition of the hip-joint associated with severe symptoms varies widely. The X-ray appearances always show reduction in the normal inter-articular space, on account of the absorption of articular cartilage; the degree of bone deformity may be slight or gross. This conforms to the rough division into atrophic and hypertrophic types. The atrophic form is most often seen in women and young adults, the hypertrophic being commoner in middle-aged and elderly men. A chronic arthritis initiated by a definite bacterial infection (e.g., the gonococcus or dysentery bacillus) will show approximately the same X-ray appearances as the atrophic type of osteo-arthritis. In those cases associated with old fractures of the

acetabulum, the appearances are influenced by the form of the primary injury. (*Figs.* 119–122.)

The choice of operation in this joint depends little, however, on the anatomical condition or etiology, but is determined by the age and general condition of the patient. In the young and middle-aged the aim should be not only to remove any pain but to provide a stable joint. This can be most effectually done by producing bony ankylosis at the joint line. An arthrodesis is most certainly produced by a complete erasion of the joint,

FIG. 119.—Hypertrophic osteo-arthritis of hip (*Case* 31).

followed by fixation in plaster-of-Paris in the position of election for a sufficient time to allow bony union to occur. This procedure was first advocated by Albee[7] in 1908. In his early series he merely rawed the upper surface of the femur and corresponding aspect of the acetabulum (*Fig.* 123). Latterly he has adopted a more thorough exposure of the joint, and further ensures bony ankylosis by the insertion of an autogenous bone graft.

The operation must be regarded as a severe one, though in my experience it is not associated with much shock. It is the prolonged after-fixation in

plaster-of-Paris in the recumbent position which is found most trying by the patient. The functional results of a fixed hip in a satisfactory position are remarkably good in the younger subjects. The most serious disability noticed as a rule by the patient is the difficulty he experiences in doing up his own boot on the side affected.

In reviewing the later results it is noticeable that elderly subjects sometimes develop pain in the lumbar spine and sacro-iliac joints after an arthrodesis of the hip. The fixation of the hip undoubtedly imposes a serious strain

FIG. 120.—Osteo-arthritis of hip with little bone change except at margins (*Case* 4).

on these joints. In elderly feeble patients an arthrodesis should not be attempted. A simple excision of the head of the femur has been most often favoured. Sir Robert Jones advises the production of a pseudo-arthrosis at the base of the neck of the femur without touching the diseased joint. Both these latter operations relieve severe pain, but leave a joint of poor stability, and mean that the patient is left dependent on the use of crutches or a walking caliper.

Sampson Handley introduced the more conservative procedure to which

he gave the name cheilotomy, but there are few cases in which this operation could be expected to give a lasting cure. Platt advocates a partial excision of the head of the femur, leaving sufficient bone to engage the upper rim of the acetabulum. This leaves, in favourable cases, a stable joint with fair mobility.

In my own experience the operation of erasion of the joint has been well tolerated by old patients, and I have merely varied the after-treatment in their case by making no attempt at rigid fixation in plaster-of-Paris. A painless fibrous ankylosis or pseudo-arthrosis is in this way obtained in a relatively short time; the hip is stable, but there is a tendency to the development of an adduction deformity.

The performance of a formal arthroplasty in the case of the hip-joint is a doubtful policy, and is hardly necessary in cases of osteo-arthritis. As stated above, a useful range of movement at the hip is obtained by an erasion of the joint followed by suitable after-treatment. Indeed, it is not easy to secure a sound bony ankylosis at the hip-joint, as is made clear by results seen in *Table I.* This experience falls in line with the frequency with which a pseudo-arthrosis is formed after an unimpacted intracapsular fracture of the neck of the femur. This suppression of new bone-formation within the joint is due to the exposure of the broken surfaces to the influence of synovial fluid; the same condition prevails after an erasion or excision of the hip for a non-inflammatory condition.

FIG. 121.—Osteo-arthritis of hip with commencing dislocation (*Case* 28).

In examining the later results (*Table I*) of cases of operation on the hip-joint, the tendency to the development of an adduction deformity is striking. This deformity results in serious functional shortening of the limb, from tilting of the pelvis when the erect attitude is assumed. As it is manifestly a complication to be avoided, it is worth while to examine the factors which are responsible for its production.

Adduction deformity is a notable feature in any case of destructive disease of the hip-joint. It appears to be due to at least two causes: (1) The proportionately excessive wasting of the gluteal muscles, which lie in intimate relation to the joint; the adductors, which are normally the master group,

are at a greater distance from the articulation and do not suffer so severely. (2) The abducting power of the glutei and tensor fasciæ femoris is reduced by the shortening of the lever (the neck of the femur) through which they act. Both these factors are operative in some degree after the operation under consideration. Firstly, the muscles may be mechanically damaged or the nerve-supply interfered with if the incision is not carefully planned; secondly, any considerable removal of bone from the head of the femur, or unusual deepening of the acetabulum, will shorten the lever through which the muscles act.

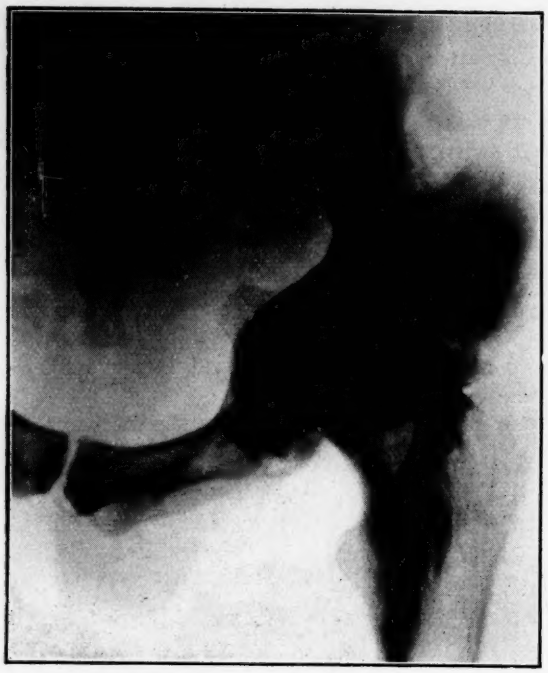

FIG. 122.—Traumatic arthritis of hip following an injury, presumably a fracture of the margin of the acetabulum (*Case* 18).

The problem of avoiding the secondary development of adduction deformity after operation only arises when a fibrous joint is the result. If firm bony ankylosis is obtained in a good position by means of proper fixation, the difficulty does not arise; but it should be remembered that sound bony union is not always obtained, however carefully the operation may be carried out, and that union, apparently firm, if due to fibrous tissue, is liable to gradual stretching.

In all cases, therefore, of operations of this nature, the two simple mechanical factors above enunciated should receive attention, viz., (1) preservation of the full function of the gluteus medius and minimus and tensor fasciæ femoris, and (2) the preservation of the neck of the femur at as full length as possible. In practice, the adductors may be weakened by section of their tendons, followed by forced abduction of the thigh. To correct the result of shortening of the neck of the femur, Whitman[8] advocates the reimplantation of the bony insertion of the gluteus medius and minimus into the shaft of the femur a couple of inches below the normal position of the great trochanter. I have no experience of this procedure, but it seems to be based on sound lines.

FIG. 123.—Diagram of Albee's method of producing a bony ankylosis in the hip-joint (1912).

The Knee.—This joint, next to that of the big toe, is probably most commonly the site of serious osteo-arthritic change. It may be said at once that, as far as current general experience goes, a radical cure of osteo-arthritis of the knee can only be obtained with certainty by arthrodesing the joint. Such a final destructive procedure can only be justified in those cases in which pain is severe and persistent, or in which absorption of the bone of the outer condyles has deformed the joint. (*Fig.* 124.)

Many minor operative procedures, favoured by the size and accessibility of the joint, have had a fair trial. The removal of detached and sessile osteophytes, and the resection of enlarged processes of the synovial membrane, are often carried out for the relief of symptoms, though it is not expected that such operations will bring the morbid process to a standstill. The more radical procedure of complete synovectomy is a practical possibility in this joint, and can be applied to a limited number of cases.[9] When practised on those in which the chief and apparently primary change is in the synovial membrane, it has given satisfactory results.

FIG. 124.—Severe osteo-arthritis of knee in a woman, age 47, with valgoid deformity.

I have found no records of a formal arthroplasty of the knee-joint in osteo-arthritis. Although the procedure cannot be regarded as likely to give a new joint permanently free from absorptive change, it should certainly be worth a trial in young patients. It is essentially conservative, and, if not successful, it should not prejudice the production of sound bony ankylosis at a second operation.

The Ankle.—Osteo-arthritic changes in the ankle are commonly originated by a trauma about the joint. It is not an uncommon sequence of infected compound fracture of the leg. The operative treatment of the condition has, in my experience, which has been limited to this type of case, been disappointing. Arthrodesis of the ankle-joint relieves the condition for a while, but is often followed after some months' use of the limb by the development of pain in the tarsal joints. The practice of arthrodesing the mid-tarsal joints at the same time as the ankle I have not found satisfactory. Pain in some part of the arch of the foot in front of the fixed joints commonly appears. I have actually carried out a Syme's amputation at the request of the patient in two cases a year or so after the complete arthrodesing operation had been done.

A simple astragalectomy I do not think is much more satisfactory. The new joint between the tibia and the os calcis practically always becomes painful and develops arthritic changes. If resection of the astragalus is followed by the establishment of an arthrodesis between the tibia and upper surface of the os calcis with the foot dorsiflexed to 80 degrees, the functional results seem to be better.

My experience of the late results of operative treatment of osteo-arthritis in this joint seems to be at variance with some authors; this is perhaps because it has been limited to cases in which widely diffused sepsis had been present at the inception of the condition.

Tarsus.—According to my observations the results of operation on the tarsal joints are not more satisfactory than those on the ankle. It seems that in the adult foot the removal of any substantial part of the bones of the tarsus imposes an irregular strain on the remaining joints, and seldom gives a good functional result. This is certainly true when the process has been associated with a pyogenic infection. In cases of simple fractures in civil practice where the arthritis is strictly confined initially to the injured joint, early operation may be more effective.

Metatarsal Phalangeal Joint of the Big Toe.—This joint is of interest in that it has furnished a mass of material from which one might expect to gather evidence of the value of operation on osteo-arthritic joints in general. The evidence, however, is not generally applicable, and certainly not in relation to weight-bearing joints. The operation undertaken has usually aimed at an arthroplasty. That generally practised takes the form of a free excision of the head of the metatarsal bone. Macausland and others practise a more conservative arthroplasty, inserting a fascial flap. In general the results of these excision operations is to leave a free or almost flail joint which cannot be subjected to much strain.

A careful examination of the late end-results of these cases is certainly needed before a final opinion can be formed on the true worth of the several methods advocated.

THE UPPER EXTREMITY.

The joints of the upper extremity, though often enough the site of an osteo-arthritic change, will less often warrant radical operation than is the case in the lower limb. The disease does not tend to progress so far as in the lower extremity, because the joints do not bear weight and can be spared a good deal of their usual share of work without completely disabling the patient. A certain number of severe monarticular instances of the disease are, however, met with; they are generally secondary to trauma. If the condition occurs in working men, operation is the only measure which will restore them to full industrial efficiency.

Acromioclavicular Joint.—Osteo-arthritis of this joint may produce a chronic disability generally recognized as a 'painful shoulder'. The excision of the joint is a minor operation which can easily be carried out, and it gives most satisfactory results if the cause of the pain has been correctly located.

The Shoulder.—The accurate diagnosis of the cause of chronic pain about the shoulder is by no means easy. Exploratory operation may be necessary to

establish it. From my limited experience of the operative treatment of osteo-arthritic conditions in this joint, I should say that, though gross bony deformity of the articular surfaces is uncommon, the minor operations undertaken for the removal of enlarged bursæ, etc., seldom give permanent relief. If radical operation is felt to be justifiable, an arthrodesis of the joint, with the humerus abducted 45 degrees from the normal and externally rotated and anteverted, probably gives the best functional result; the scapular movements being sufficient to secure a useful control of the position of the arm. A simple conservative resection of the head of the humerus is a better procedure if for any reason the movements of the scapula are restricted; or in elderly patients in whom the prolonged fixation which an arthrodesis requires is undesirable.

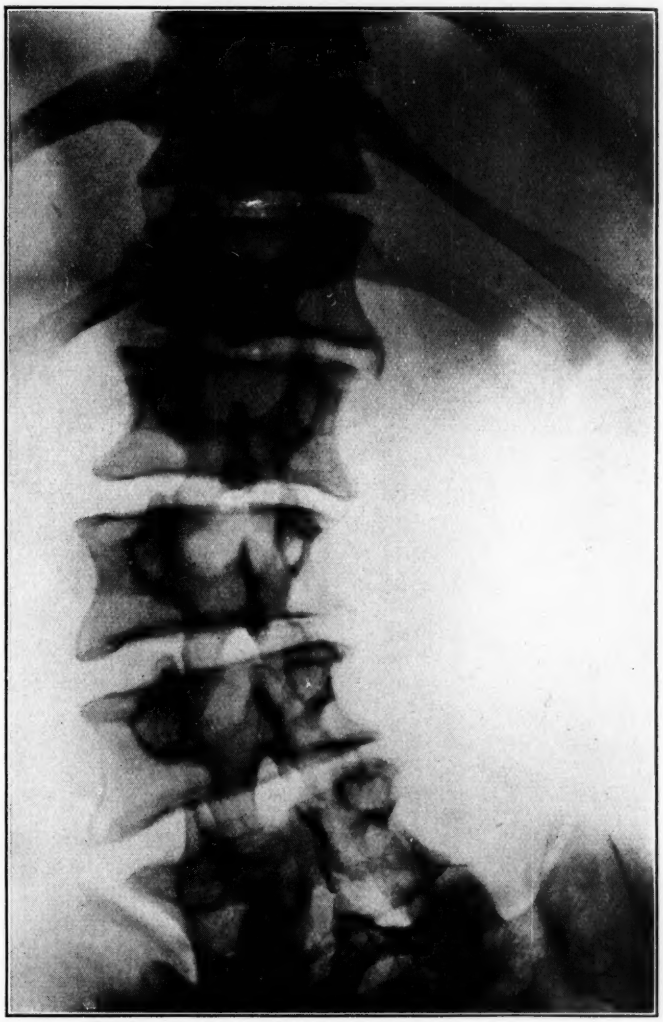

FIG. 125.—Traumatic spondylitis in a man, age 33.

The Elbow.—Cases submitted to operation will usually be secondary to injury, and undertaken in the working period of the patient's life. The decision between an arthroplasty and an arthrodesis will be based on social grounds. An arthrodesis between the elbow and humerus with the elbow set at an angle of about 130 degrees gives a very useful arm for a worker, provided that the head of the radius is freely excised, so that the movements at the radio-ulnar joints are maintained. An arthroplasty is better suited to women, and to men whose occupation is of a sedentary character.

The Wrist and Carpal Joints.—Osteo-arthritis of these joints is most often seen as the late sequel of carpal injuries. Operation will be undertaken for persistent pain rather than for limitation of movement. In my experience of some eight cases, excision of the proximal row of carpal bones, though very

often satisfactory in its immediate results, is disappointing later, a recurrence of the symptoms being common. A complete excision of the carpus is advocated by Vallas[10] for this condition. My experience of this somewhat drastic procedure is limited to two cases, and the final results showed little improvement on the primary condition.

FIG. 126.—Spondylitis deformans in a man, age 36, showing ossification of intervertebral ligaments and little other change.

In a working man the disablement is a serious one, and the poor results obtained by operation once the osteo-arthritic process is established enforces the importance of the careful early handling of cases of carpal injury.

Temporomaxillary Joint.—A disabling arthritis of this joint is most often met with in women. An excision of the condyle relieves the pain and leaves a useful joint. A shortcoming of the procedure is the slight deviation of the lower jaw towards the operated side which is involved.

The Spine. — The types of chronic change which can be recognized from the X-ray appearances can be roughly divided into two groups, viz.: (1) Those in which the bony changes are most in evidence, absorption of the bodies and marginal lipping being present (*Fig.* 125); (2) Those cases in which ossification of the intervertebral ligaments is the prominent feature (*Fig.* 126).

In the latter type the serious clinical symptom is fixation of the spine due to bony deposit in the ligamentous structures. This is not subject to surgical control, and treatment must therefore be limited to prevention of deformity while the process is active, and to the securing of ankylosis in

an erect posture. The condition occurs in what is termed the Marie-Strümpell type of arthritis, and is often associated with involvement of the large joints of the extremities.

In the first-mentioned condition, which is more properly classified as one of osteo-arthritis and is generally termed traumatic spondylitis, the progressive absorption of bone may lead to severe pain from pressure on the emerging nerve roots. In such cases the possibilities of ankylosing the spinal processes by means of Albee's or Hibbs' method is worth considering in selected cases. I have undertaken two operations of this kind, but at too recent a date to be able to form any opinion as to the value of the final result. If operation is carried out for this condition, it appears to me to be difficult to determine what extent of the spine should be fixed. I attempted to arthrodese the whole of the lumbar spine in both cases referred to.

Sacro-iliac Joints.—Some prominence has lately been given to the pain arising in these joints, and it has been termed sacro-iliac strain. In a great number of instances the condition appears to be due to an active osteo-arthritis of the joint. When the obstinacy of the case justifies it, an arthrodesis would appear to be the best method of operative treatment, and this has been carried out by bone-grafting in a plane posterior to the actual joint. I have no personal experience of the results of the procedure.

TECHNIQUE OF OPERATION ON THE HIP-JOINT.

A good exposure of the hip-joint is not very readily obtained in a stout adult, and for any operation aiming at an erasion of the joint a good field of view is most important. The surgical approaches to the joint have been subject to a good deal of study,[11] and I propose only to outline those methods of which I have personal experience, and to examine the relative merits in relation to the subject under discussion.

In 35 consecutive operations carried out for chronic arthritis I have employed three routes, the posterior, the superolateral, and the supero-anterior.

The Posterior Incision (*Fig.* 127).—An oblique skin incision about 8 inches in length is made, starting at a point over the posterior inferior iliac spine, and extending forwards and downwards, terminating just external to the anterior margin of the great trochanter of the femur. The underlying gluteus maximus is split in the length of the incision; the sections are then retracted upwards and downwards to expose the posterior and upper aspect of the capsule of the hip-joint. The view is somewhat obscured by the pyriformis and gemelli. These may have to be divided to gain access to the joint, but retraction is often sufficient. This incision does not give a good field of view, and it may be difficult to recognize the exact position of the joint margin. Dislocation of the head of the femur cannot be effected with ease or certainty. I have employed

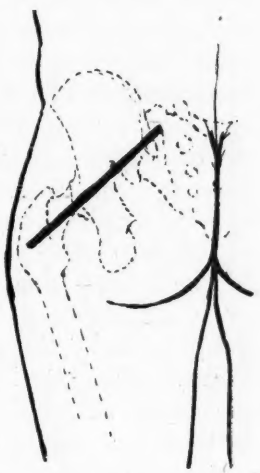

FIG. 127.—Diagram of skin incision: posterior approach.

this incision in five cases, but have given it up on the grounds stated above.

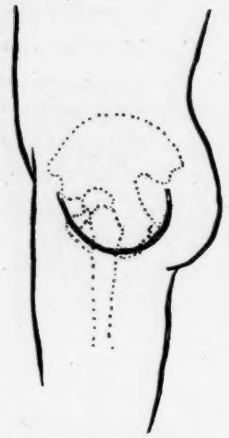

FIG. 128.—Diagram of skin incision: supero-external approach.

The Supero-external Route (*Fig.* 128).—This is based on that described by Murphy in his operation for arthroplasty of the hip, and also by Lexer. A skin flap is turned up representing a third of a circle: the anterior termination of the arc is brought over the anterior inferior spine, and the posterior lies in a similar relation to the posterior inferior spine. The flap is turned up on its base (*Fig.* 129); the underlying aponeurotic tendon of the gluteus maximus is divided in line with the anterior margin of the great trochanter. The tendinous flap is retracted backwards, exposing the great trochanter. This process of the femur is then cut through obliquely ¾ in. from its upper margin with a wide thin-bladed osteotome. The detached fragment of bone is drawn upwards with a sharp hook, and with it the insertions of the gluteus medius and minimus, pyriformis, and gemelli; the anterior margin of the gluteus medius is dissected away from the posterior aspect of the tensor fasciæ femoris in order to free the flap. A good exposure of the upper and posterior surface of the joint is so obtained; the joint line can be clearly recognized by a rotation of the thigh (*Fig.* 130). The capsule of the joint is incised from above downwards and backwards. The head of the femur can then be dislocated backwards by an assistant. The knee is bent to a right angle and the thigh partially inverted in order to effect this. Access to the acetabulum is obtained by a suitable manipulation of the position of the head of the femur. The joint surfaces of the head of the femur and acetabulum can then be cut away with a broad gouge. The head of the femur is dropped back into place, and the great trochanter and the overlying aponeurosis are then re-sutured in place. I have used strong catgut for the purpose, and have always secured bony union of the trochanter and shaft.

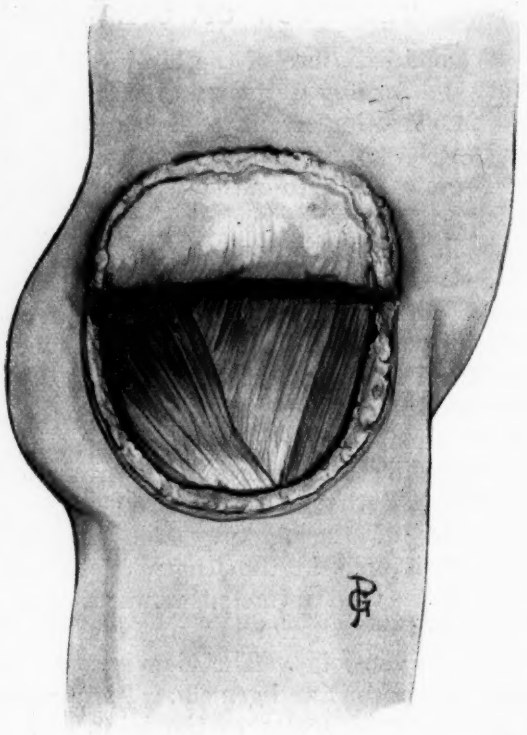

FIG. 129.—Diagram of area exposed by the skin flap in supero-external approach.

This route gives a good exposure of the joint, though in cases in which there has been gross deformation of the head of the femur complete dislocation may be found difficult or even impossible. The operation involves no division of blood-vessels of any size, and is absolutely conservative in regard to muscle function. I have used the method in twenty cases, and consider it certainly the most satisfactory for old patients on account of the rapidity with which it can be carried out and the small amount of muscle section which is necessary.

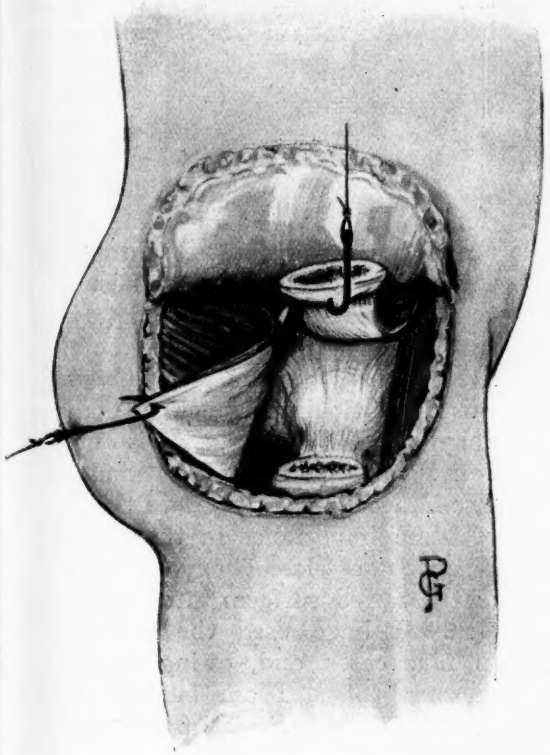

FIG. 130.—Supero-external approach: exposure completed.

The Supero-anterior Approach.—This route was introduced in the early part of the century by Sprengel in Germany and by Anderson in England for operations on tuberculous disease of the hip-joint. The method was again described in detail by Smith-Peterson[12] in 1912.

The skin incision (*Fig.* 131) is angulated, and consists of an upper curved section about 4 inches in length, parallel to and just below the anterior half of the iliac crest, and a vertical cut made from the anterior extremity of this incision directly downwards for about 5 inches. This vertical part of the incision lies over the border of the anterior portion of the tensor fasciæ femoris. The muscles are divided in the line of the skin incision; in the upper sector the origins of the gluteus medius and the tensor fasciæ femoris are cut through half an inch below the iliac crest (*Fig.* 132). In the vertical sector the fascia lata is divided at the anterior border of the tensor fasciæ femoris. The muscle flap so outlined is then separated from the underlying tissues, the gluteus medius being raised from the outer aspect of the venter of the ilium together with the underlying gluteus minimus. This exposes freely the front and upper aspect of the hip-joint, the reflected head of the rectus femoris lying immediately above it. In order to dislocate the head of the femur, the front part of the capsule must be incised and the outer border of the

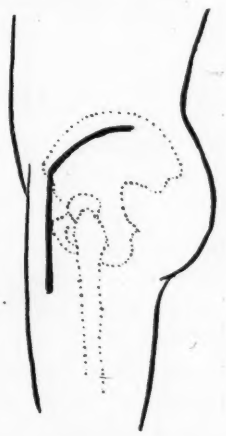

FIG. 131.—Diagram of skin incision: supero-anterior approach.

iliofemoral ligament divided. Dislocation is effected by an assistant strongly everting the thigh, after the latter has been flexed to a right angle.

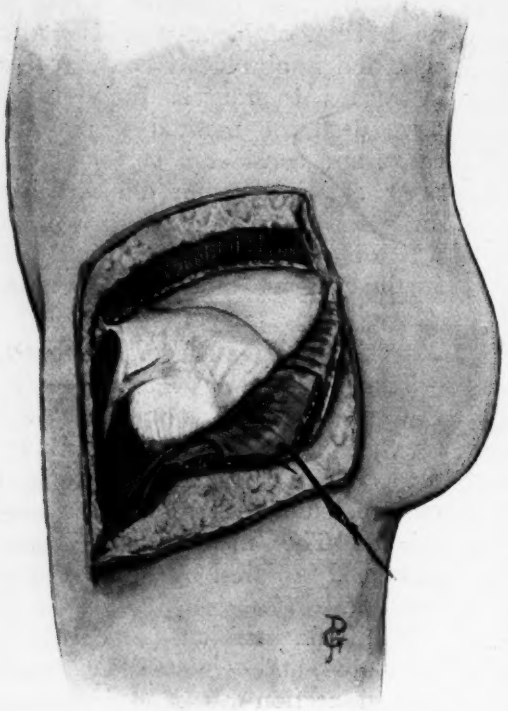

FIG. 132.—Supero-anterior approach: the muscle flap turned down.

This incision gives the fullest exposure of the joint, and renders the accurate recognition of the bony parts very easy. In children the gluteal flap can be raised subperiosteally, but in the adult this is not possible, and the separation of these muscles from the bone involves a good deal of minor bleeding. If the head of the femur is dislocated through this approach in order to effect a complete erasion of the joint, it should be noted that the iliofemoral ligament must be damaged; though this is of no importance if bony ankylosis is secured, it is not desirable if a movable joint results. The intact ligament is also, I think, of some importance in the maintenance of close bony contact of the rawed surfaces after operation. I have used the incision in nine cases, and, owing to the reasons stated, I am inclined to consider it not as satisfactory as the supero-external route.

TECHNIQUE OF OPERATION ON THE KNEE.

Excision of the Knee (*Figs.* 133–136).—When undertaken in osteo-arthritis the aim of this operation is the production of sound bony ankylosis in a slightly flexed position. Classical methods, though usually successful in securing this result, occasionally fail, and union is established by fibrous tissue. The factors which may lead to union of this character appear to be three, viz., (1) sclerosis of the bone surfaces apposed, (2) lack of close contact between the prepared surfaces, and (3) the access of synovial fluid to the cut bone. The incidence of these factors can be prevented by attention to the following details: (1) The synovial pouch should be dissected out, the bulk of the synovial tissue in the joint being in this way removed; (2) The section of bone should be so planned that vascular cancellous bone is exposed everywhere except at the margins; (3) I have usually assured close apposition of the cut bone surfaces, without any special splinting, by pulling the patella down to the level of the tibia and pegging it in position there. The articular cartilage of the patella is previously cut off. The bone is most effectively

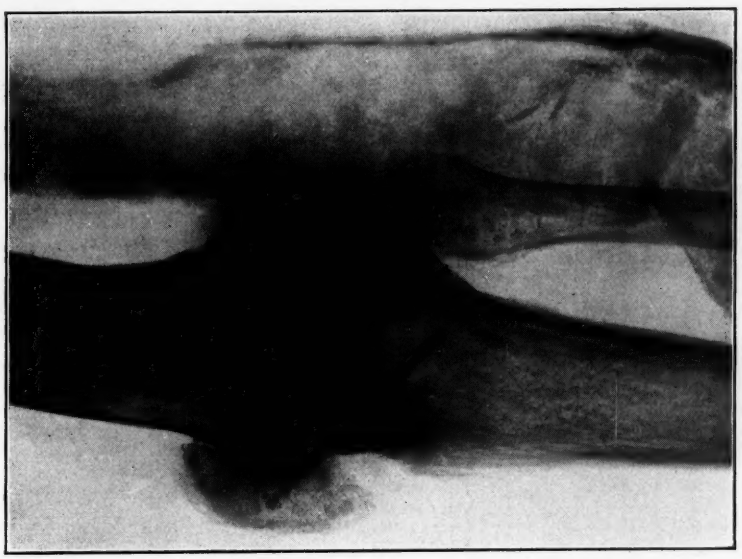

FIG. 135.—Side view of excised knee. Fixation secured by the use of beef-bone pegs.

FIG. 134.—Side view of case shown in *Fig.* 133, after an autogenous key graft had been inserted to secure bony union: X-ray three months after second operation.

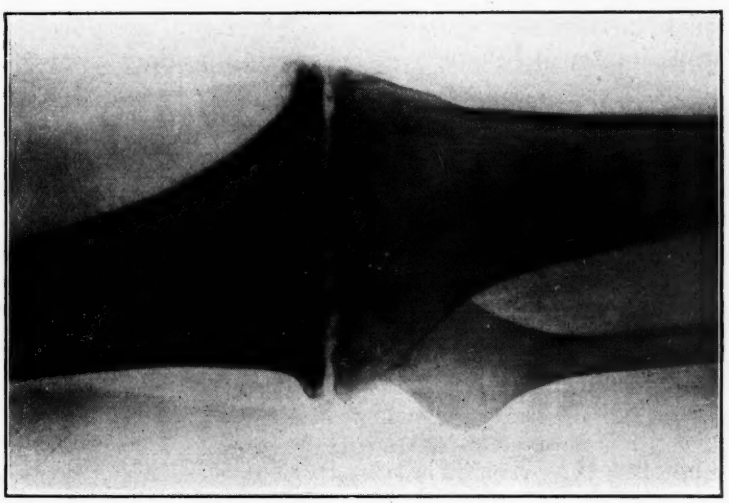

FIG. 133.—Fibrous union present in a knee excised two years previously. Male, age 42.

held by means of a long French nail. This procedure holds the bone surfaces firmly in contact by the tonic pull of the quadriceps muscle and its opponents. The method has the practical advantage that the cut surfaces are so firmly held in position that it is unnecessary to use plaster for fixation of the limb after the operation, a simple gutter excision splint being applied. A close-fitting plaster case can be fitted in a week or so after the skin stitches have been removed.

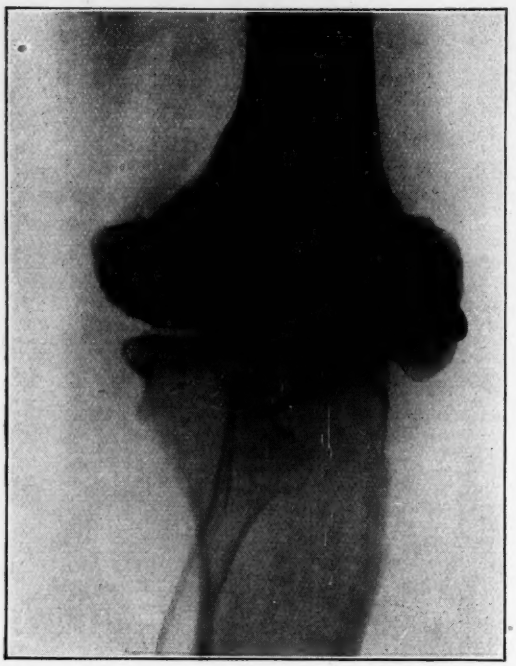

FIG. 136.—Excision of knee fixed by nailing patella to tibia.

The only drawback to this method is that the pull of the quadriceps may be sufficiently strong to angulate the joint forwards, opening up the posterior aspect of the cut surfaces. This tendency can be controlled without difficulty when the plaster case is applied. This form of the operation can be carried out if the usual U flap of skin be turned up, but I think an H-shape incision is better. It gives full access to the operation area without involving the risk of marginal sloughing of the skin flap.

AFTER-TREATMENT.

Hip-joint.—The form of the after-treatment adopted is determined according to whether bony ankylosis is desired, or whether fibrous union at the joint is deemed sufficient. In young healthy subjects the satisfactory final results of an arthrodesis will settle the question. In elderly or feeble patients a fibrous joint will be accepted in order to minimize the discomforts of after-treatment.

In order to obtain bony union, I think satisfactory fixation in plaster-of-Paris is essential. A single spica extending from below the ribs to the foot is applied immediately after operation. The thigh is set in the position of election, viz., slight abduction, 20 degrees of flexion, with the foot slightly everted. The first plaster is changed in about a fortnight, when the wound stitches can be removed, and another is applied. The second plaster must control the abduction, and if this cannot be done by moulding the plaster on the pelvis, coupled with an extension to the axilla on the opposite side to the injury, the sound leg should be included. At six or eight weeks after operation the plaster is cut away in order to free the knee-joint. At eight to twelve weeks the patient can get about with crutches, retaining a short spica for another month. Weight-bearing is allowed during this period. At

three to four months after operation the plaster is removed and the condition of the joint examined radiologically; if union is firm, the patient can be allowed to walk with sticks. Full return of function cannot be expected under six months from operation, and may be deferred for twelve.

The ideal position for fixation of the hip varies somewhat in relation to the occupation of the patient. Flexion beyond 20 degrees involves considerable compensatory lordosis of the lumbar spine when the erect position is adopted. For this reason flexion in an outdoor labourer should not exceed that degree. In cases in which the patient wants to be able to drive a car of standard proportions, flexion to 30 degrees must be given unless the man is very short. *Case* 20 is a good example of the functional result obtained in such cases; twelve months after operation he was able to pass the police taxi test, and now drives a cab daily.

Some fixation of the knee commonly follows the prolonged immobilization in plaster, but it is only likely to be permanent in elderly patients, the full range being restored on the average after a few weeks' physical treatment.

When the aim is fibrous union, after operation the limb is slung in a Hodgen's or similar splint and a light extension applied. The position maintained should approximately be that of election already described. The extension is removed at the end of three or four weeks, and the patient allowed to get up on crutches swinging the damaged leg. Weight-bearing is not encouraged till six weeks after operation. Though the period during which the patient is confined to bed is reduced, the final return of function is usually less rapid and less satisfactory than when an ankylosis is obtained.

The Knee-joint.—When the knee has been excised by the method described above, a simple metal gutter splint is applied, extending from the tuber to the lower part of the calf, for a couple of weeks. It is then replaced by a close-fitting plaster cast extending from the tuber to the malleolus. The patient gets up in from four to six weeks after operation, and walks with crutches for a month or so, gradually putting more weight through the joint. Union is generally firm in from three to four months.

LATE RESULTS OF OPERATION.

The Hip-joint.—In the estimate of the final results of these operations on the hip the views of the patient and surgeon are somewhat different. The former is well satisfied if he loses his pain and is left with a limb whose functional value is not worse than before operation. The surgeon, on the other hand, recognizes that the removal of the pain is readily effected, and looks rather for an improvement in the functional value of the limb. In either case the true merit of the procedure can only be fairly assessed by a study of the results some years after operation. This particularly applies if operation is undertaken during the active period of the patient's life, when the resulting function of the limb is almost as important as the relief of pain.

The evidence in the literature on the subject is somewhat meagre, only a few authors having published the details of the late results of any considerable number of cases. The outcome of operations aiming at arthrodesis have received the most attention.

Table I.—**34 CASES OF OSTEO-ARTHRITIS**

No.	Name	Age and Sex	Side	Date of Operation	Condition and Etiology	Operation	Approach	Latest Date Observed	Condition of Joint
1	Pens. S.	32 M.	R.	1.12.19	2 years treated as tuberculous hip. X-ray and histological examination showed chronic arthritis	Partial erasion. Head not dislocated. Fixed in plaster 2 months	Supero-anterior	1.2.24	Bony ankylosis
2	F. F.	69 M.	R.	5.2.20	8 years progressive hypertrophic osteo-arthritis. Partial dislocation. Adduction and flexion +. Muscle spasm +	Partial erasion. Head not dislocated. Poorly fixed in plaster 6 weeks	Posterior	6.7.22	Fibrous fixation, 10° movement
3	K. H.	43 F.	R.	6.3.20	3 years increasing pain and stiffness. Osteo-arthritis	Partial erasion. Head not dislocated. Fixed in plaster 2 months	Posterior	30.1.24	Fibrous joint
4	A. K.	60 M.	L.	4.4.20	10 years pain and stiffness. Hip flexed and adducted. Hypertrophic osteo-arthritis	Erasion of joint. Tenotomy of adductors. In plaster 2 months	Supero-lateral	10.1.24	Fibrous fixation
5	Pens. E.	34 M.	L.	17.5.20	Fell from lorry 18 months before. X-ray: no fracture. Traumatic arthritis	Complete erasion of joint after dislocation. In plaster 2½ months	Supero-lateral	3.4.22	Bony ankylosis
6	E. D.	48 F.	L.	29.5.20	4 years pain. Osteo-arthritis	Partial erasion. In plaster 6 weeks	Posterior	16.1.24	Firm ankylosis but not bony, by X-ray view
7	Pens. P.	42 M.	L.	3.8.20	2 years ago fractured neck of femur. Painful false joint	Excision of head of femur. Arthrodesis attempted by bone peg and fixation in plaster	Supero-lateral	1.2.23	Non-union, false joint
8	W. S.	45 M.	L.	20.11.20	2 years ago fractured neck of femur. Union in bad position. Secondary arthritis	Partial excision of head. Fixation in plaster	Supero-lateral	10.1.24	New joint stable. Painless movement through 20°
9	Pens. F.	24 M.	R.	1.1.21	Ununited fractured neck of femur complicating paraplegia of obscure origin (? acute myelitis) 2 years. Hip flexed and adducted	Excision of head. Arthrodesis of neck without bone peg. In plaster 2 months	Supero-lateral	4.6.22	Arthrodesis. Bony union
10	S. B.	55 F.	L.	16.1.21	Osteo-arthritis, monarticular. 5 years increasing pain. Spasm +	Erasion of joint after dislocation	Supero-lateral	4.1.24	Arthrodesis clinically. X-ray does not show sound bony union
11	Pens. W.	38 M.	L.	4.4.21	2 years pain in hip. ? Psoas abscess, suspected of T.B. X-ray and microscopic: osteo-arthritis	Erasion of joint. Head dislocated	Supero-lateral	4.4.21	Bony ankylosis

OF HIP-JOINT TREATED BY OPERATION.

Position	Pain in Hip	Pain in Other Joints	Functional Shortening	Functional Value	Remarks
Normal, flexion 5°	None	—	½ inch	Good. Working as a carter in 1922, full day, continues to do so	Walked with sticks 10 weeks after operation. Finds sitting awkward on account of absence of flexion at hip
Adduction 15° Foot everted	None	—	4 inches	Fair. Can stand about without discomfort. Walks with stick	Patient had become addicted to morphia before operation on account of pain. There was much spasm of the hamstrings, which made fixation in plaster splint difficult
Adducted 5°	None	—	1½ inches	Can do all housework. Fair	Pyorrhœa +. Knee remained stiff after operation for some months. Did not walk without crutches for 4 months. Now occasional pain and stiffness in R. knee
Adducted 5° Flexed 20°	None	—	2 inches	Fair, but unable to resume old work as carter	
Abducted 5° Flexed 10°.	None	—	None	Very good	Returned to work, but committed suicide in 1922, said to be due to family worries
Slight adduction. Flexed 10°	None	—	1 inch	Can walk about 2 miles in comfort	Patient was very stout and was difficult to fix in plaster. Very slow in recovering general ambulatory function (5 months)
Adducted	Occasional	—	3 inches	Poor. Walks fairly in caliper	Arthrodesis failed in this case
Adducted 15°	None. Pain in L. groin after long day	—	3 inches	Good. Does full day's work as gardener	Original aim at procuring an arthrodesis failed. Present joint seems useful, but X-ray suggests progressive absorption of bone
Adducted 5°	None	Nil	2 inches	Incomplete recovery of paraplegia. Could walk 6 months after operation	Final result not observed
Adducted 10°	None	None except for occasional stiffness in R. hip	1½ inches	Can walk 2 miles on end and stand any length of time	Patient was of stout build and difficult to control in plaster
Normal, flexed 20°	None	Some pain in L. knee and back	1 inch	Good	Patient of poor physique and lacking in enterprise; has not yet returned to work. Pain in back probably secondary to too great flexion of hip-joint

Continued on next page

Table I.—**34 CASES OF OSTEO-ARTHRITIS O**

No.	Name	Age and Sex	Side	Date of Operation	Condition and Etiology	Operation	Approach	Latest Date Observed	Condition of Joint
12	Pens. C.	43 M.	L.	8.5.21	Dysentery 1916, followed by arthritis of spine and hips. Painful partial ankylosis of both hips	Erasion of joint after dislocation	Supero-lateral	27.1.24	Bony ankylosis
13	W.W.	60 M.	L.	3.6.21	Progressive hypertrophic osteo-arthritis	Erasion of joint after dislocation. Fixed in plaster 2 months	Supero-lateral	4.7.23	Fibrous union. 1 movement
14	Pens. D.	34 M.	R.	29.8.21	Osteo-arthritis. Few years increasing pain and stiffness	Partial erasion, dislocation not possible	Supero-anterior	3.4.23	Firm fibrou union
15	Pens. Gil.	37 M.	R.	20.10.21	Traumatic arthritis following gunshot wound of hip, non-suppurative	Excision of remains of head of femur. Arthrodesis with beef peg	Supero-lateral	4.11.23	Bony anky losis. Pe broken an partly a sorbed
16	Pens. Greg.	34 M.	L.	7.11.21	Traumatic arthritis following gunshot wound. Painful hip fixed by spasm	Excision of head. Arthrodesis with beef peg	Supero-lateral	10.12.23	Bony ankylosis
17	L. L.	51 F.	L.	24.1.22	Osteo-arthritis of hip 3 years. Early osteo-arthritis of both knees	Erasion of joint after dislocation of head. In plaster 2 months	Supero-lateral	7.9.23	Fibrous. ankylosis, fe degrees of movement only
18	Pens. M.	30 M.	L.	9.2.22	Traumatic osteo-arthritis. Hip stiff 4 years following an injury	Partial erasion of joint. Dislocation not complete. Plaster 2 months	Supero-anterior	1.2.24	Clinically, arthrodesis. X-ray, ankylosis.
19	J. E.	51 M.	L.	16.2.22	Osteo-arthritis. Wearing caliper splint 18 months	Erasion of joint after dislocation. Plaster fixation	Supero-lateral	7.1.24	Bony ankylosis
20	R. L.	52 M.	L.	25.4.22	Hypertrophic osteo-arthritis 5 years	Erasion of joint after dislocation. Plaster 7 weeks	Supero-lateral	25.1.24	Bony ankylosis
21	Pens. N.	43 M.	L.	19.5.22	Arthritis of hip following enteric in 1919. X-ray appearances: osteo-arthritis	Erasion of joint without complete dislocation	Supero-lateral	1.2.24	Fibrous joint, 10° o movement
22	W.W.	66 M.	L.	6.6.22	Hypertrophic osteo-arthritis 5 years	Erasion of joint after dislocation. Fixed in plaster 6 weeks	Supero-lateral	9.11.22	Clinically ankylosis
23	H. B.	59 M.	L.	29.6.22	Hypertrophic osteo-arthritis 2 years	Erasion of joint after dislocation. In plaster 2 months	Supero-lateral	10.10.23	Fibrous fixation. Few degrees of movement

HIP-JOINT TREATED BY OPERATION—*continued.*

OSITION	PAIN IN HIP	PAIN IN OTHER JOINTS	FUNCTIONAL SHORTENING	FUNCTIONAL VALUE	REMARKS
Slight duction, exed 15°	None	Occasional in back	—	Can walk a few hundred yards	Arthroplasty of R. hip 5.3.21. Spine is stiff and kyphotic
dducted 10°	None	L. knee occasional	1½ inches	Fair	Had not returned to his work as engine-driver in July, 1923
dducted 1°	None	None	1 inch	Good	Returned to work as barman 7.7.22
dducted lightly, exed 15°	None	None	2 inches	Good	Returned to work as upholsterer
dducted 10°, exed 20°	None	Slight in lumbar spine	2½ inches	Good	Walked without stick 5 months after operation
Slight duction	Occasional in L. groin	In L. knee and both sacro-iliac areas	1½ inches	Poor 1½ years after operation. Could walk a mile or two	Swelling of whole 2 weeks after operation. No infection. Swelling gradually settled down, but L. knee somewhat stiff. Sacro-iliac pain was relieved in some measure by a Goldthwaite belt. Poor-hearted patient.
bducted 5°, exed 10°	None, or slight in groin and thigh	None	None	Good. Works daily as milkman	Complained of awkwardness in sitting down due to slight degree of flexion of hip
dducted 5°, lexed 15°	None	Occasional in L. knee	1½ inches	Good. Can walk 'any' distance	Returned to work as barman
Slight duction, exed 30°	None	None	1½ inches	Good	In 1923, passed Metropolitan Police examination as taxi-driver, and now working as such. Unusual flexion of hip given on account of occupation.
Normal	Slight after heavy work in wet weather	None	1 inch	Good	Working as liftman
Normal, everted foot	None	None	1 inch	Walking with sticks	Died, March, 1923: said to be from pneumonia
dducted 10°, exed 15°	Some in groin	L. knee stiff and painful	2 inches	Poor. Could walk about a mile with a stick	Developed swelling in both legs 6 months after operation. Possibly due to venous thrombosis. Under medical treatment for emphysema and myocarditis

Continued on next page

Table I.—**34 CASES OF OSTEO-ARTHRITIS OF**

No.	Name	Age and Sex	Side	Date of Operation	Condition and Etiology	Operation	Approach	Latest Date Observed	Condition of Joint
24	F. T.	37 F.	L.	28.9.22	Osteo-arthritis of hip 2½ years, much pain in knee	Erasion of joint after dislocation. Plaster 2 months	Supero-lateral	28.1.24	Bony ankylosis
25	A. W.	50 M.	L.	5.12.22	Hypertrophic osteo-arthritis 6 years, progressive	Erasion of joint after dislocation. Plaster 7 weeks	Supero-anterior	23.12.23	Fibrous joint, 10° movement
26	G. N.	59 M.	R.	2.1.23	Traumatic osteo-arthritis. Fell and broke ankle and hurt hip 3 years ago	Erasion of joint after dislocation. Plaster 6 weeks	Supero-lateral	24.1.24	Clinically ankylosed. X-ray doubtful
27	C. D.	48 F.	R.	15.5.23	Osteo-arthritis of hip. Pain 2 years. Pott's fracture of R. ankle 8 years ago, position poor	Erasion of joint after dislocation. Plaster 2 months	Supero-anterior	7.11.23	Bony ankylosis
28	Pens. P.	33 M.	R.	7.2.23	Hypertrophic osteo-arthritis with commencing dislocation	Erasion of joint after dislocation	Supero-lateral	2.2.24	Bony ankylosis
29	Pens. Strat.	38 M.	L.	7.5.23	Traumatic arthritis following fracture of acetabulum. Great flexion and adduction deformity at hip	Partial excision of joint. Dislocation impossible. Plaster 2 months	Supero-anterior	23.11.23	Bony ankylosis
30	G. W.	64 M.	L.	10.6.23	Hypertrophic osteo-arthritis	Erasion of joint after dislocation. No plaster fixation. Light extension 6 weeks	Supero-anterior	24.1.24	Fibrous joint, rather high in acetabulum
31	H. S.	48 M.	L.	27.9.23	Hypertrophic osteo-arthritis	Erasion of joint, 4 lb. extension. On crutches in 5 weeks	Supero-anterior	24.1.24	Fibrous joint, 20° of painless movement
32	H. P.	73 M.	R.	4.10.23	Hypertrophic osteo-arthritis 5 years	Erasion of joint after dislocation. 4 lb. extension	Supero-anterior	—	—
33	Lt.B.	24 M.	R.	2.11.23	Chronic painful arthritis 2½ years	Erasion of joint after dislocation. In plaster 8 weeks	Supero-anterior	28.1.24	Clinically ankylosed
34	G. L.	43 M.	L.	1.8.22	Hypertrophic osteo-arthritis	Erasion of joint after dislocation. Fixed in plaster	Supero-anterior	27.1.24	Fibrous fixation

HIP-JOINT TREATED BY OPERATION—*continued.*

Position	Pain in Hip	Pain in Other Joints	Functional Shortening	Functional Value	Remarks
Normal, slight eversion, flexed 15°	None	Some pain in R. hip, both sacro-iliac joints	2½ inches	Can walk 3 or 4 miles	A very short woman. Sacro-iliac pain improved by wearing belt.
Adducted 10°, flexed 15°, eversion +	None	Pain and stiffness L. knee	2 inches	Can walk a good distance with a stick	Returned to work as carpenter, Nov., 1923
Adducted 5°, flexed 15°	None	None	1½ inches	Good	
Adducted 10°, flexed 15°	None	In R. knee and ankle	2 inches	Fair	Walks with stick, but improving in regard to general function
Slight adduction	None	None	1 inch	Good	Could walk 1 to 2 miles 10.11.23. At work as liftman 2.2.24.
Flexed 15°, adducted 10°	None	None	1½ inches	Good	Complete reduction of flexion deformity was easily effected, but full reduction of adduction found impossible
About 20° of movement	Slight	None	2 inches	?	Walks 2 or 3 miles with a stick 24.1.24
—	Some in groin after walking	None	2 inches	?	Walks 2 or 3 miles with a stick, hip still feels weak 24.1.24
—	—	—	—	—	Died 10 days after operation. P.M.: cellulitis of wound; trabeculated bladder; cirrhotic kidneys. Uræmic symptoms developed 3 days after operation
Normal. Flexed 15°	None	None	None	Good	Walking in short spica 27.1.24
Adducted 15°, flexed 20°	Some in groin and thigh	Some in back	2 inches	Poor. Can walk half a mile	The resulting position 9 months after operation was fair; flexion and adduction increased latterly, and account for poor end-result

Ozarki[13] in 1917 records the results of the arthrodesing operation of the hip in ten cases of polyarticular arthritis and sixteen of the monarticular variety. The same cases were reported on a few years later.

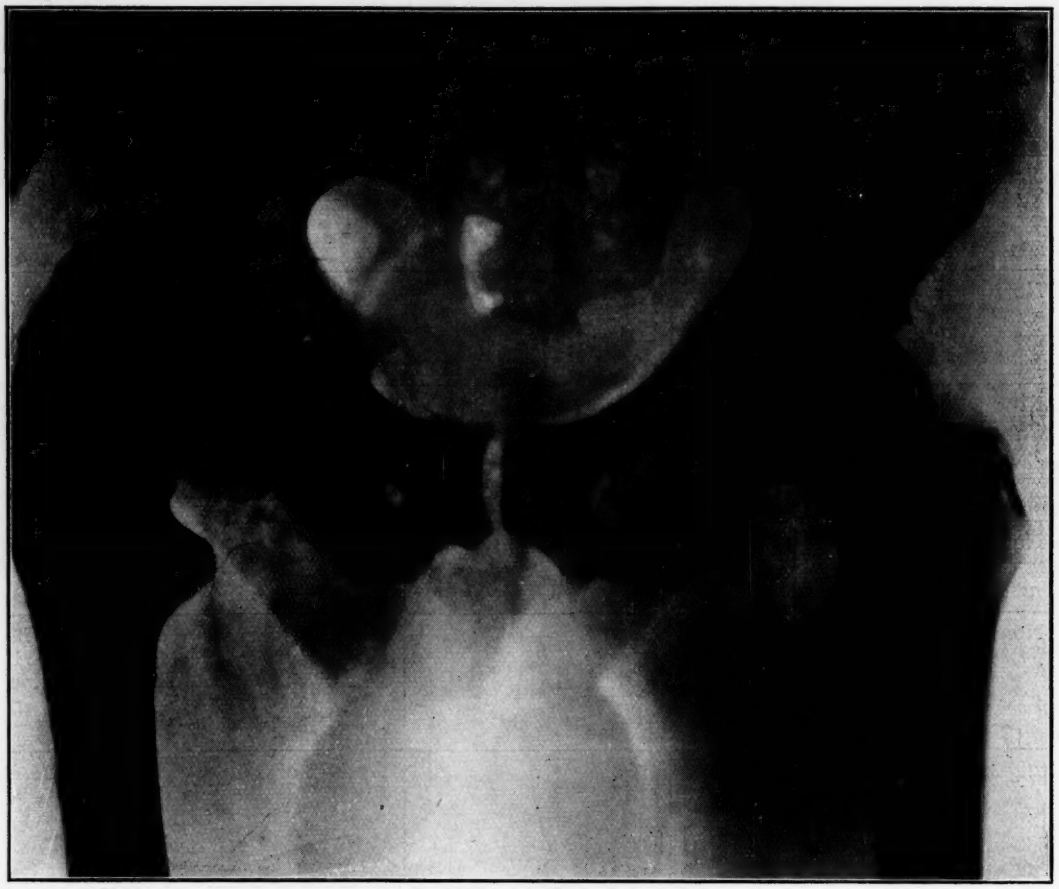

FIG. 137.—Result of operation in *Case* 20: two years after operation: bony ankylosis.

In 1920 Spiers,[14] in a careful survey of the late results of all the cases operated on between 1908 and 1920 at Brackett's clinic, sets them out in tabular form as follows :—*

Cases operated on	34
Cases examined later and reported	25
Average age	46
Youngest	22
Oldest	61
Case mortality	2
Average interval since operation	4½ yrs.

RESULTS OF EXAMINATION.

Union :	Union firm	17	*Position :*	Adduction present in	18
	,, questionable	3		Normal	4
	Non-union	5		Abduction present in	3

* These cases presumably include those reported in 1917 by Ozarki.

He found that in the cases unrelieved by operation, arthrodesis had not been secured.

Albee[7] in 1921 reported that he had operated on 128 cases with satisfactory results. Details of these cases in regard to the technique of operation and the late results are not published.

The results of the operation of excision of the head of the femur for this condition have not been reported in any large series. Individual experience

FIG. 138.—Result one year after operation in *Case* 24 : bony fixation, with head of femur displaced somewhat upwards.

appears to vary. Pain is relieved in all cases, but the functional value of the joint is reported on as a whole unfavourably, considerable shortening being the rule, and stability uncertain (Fock[3], Zezas[4], Müller[6], and Hoffa[15]).

Platt has reported to me that he has carried out a modified excision in some twenty cases. He considers that though pain is thereby relieved surely, the average function given by this operation is disappointing.

I have operated on 34 cases of chronic arthritis of the hip from 1919 to date. Details of these cases are given in *Table I.* The series is made

up of the following types: Monarticular osteo-arthritis, 28; polyarticular osteo-arthritis, 1; traumatic osteo-arthritis, 5. (*See Figs.* 137–142.)

In the 29 cases operated on for chronic arthritis, an erasion of the joint was effected by one of the methods previously described. After-treatment was carried out with a view to obtaining bony ankylosis in 23 cases, and a fibrous joint in 6. Six of these cases were operated on in 1923, and therefore are of no value in assessing the late results.

FIG. 139.—Result of operation for osteo-arthritis of hip: fibrous joint: X-ray eighteen months after operation (*Case* 25).

Table II gives in outline the late reports of the 24 cases in which operation was carried out between 1919 and 1922. The average age of these cases was 47·5, the oldest was 69 and the youngest 28. The results tabulated were obtained by clinical and X-ray examination made within the last few months. Three of these cases were not examined recently, one having died of pneumonia, one having committed suicide for domestic reasons, and the other reporting from the country. The statements in regard to the absence of pain are based on the patients' opinion, and refer to the original joint pain.

The term 'slight pain' is applied to those cases in which ill-defined pain in the groin or thigh was complained of after fixation. The estimate of the functional value of the limb is necessarily approximate. No hard-and-fast classification is possible when dealing with this condition, the results varying in relation to the age of the patient, and the preceding period and degree of disability. The term 'good' has been applied when the patient could walk about five miles without any support, and do a fair day's work. 'Fair' implies the ability to walk about two miles and to stand about half an hour without fatigue. The category 'poor' is applied to those cases in which the ability to walk was limited to a mile or less.

Table II (abstracted from Table I).—General Results in 24 Cases of Erasion of Hip-joint Reviewed at least One Year after Operation.

Condition of Joint		Position		Pain in Hip		Functional Shortening	Functional Value	
Bony ankylosis	9	Normal ..	3	Absent ..	19	Average in inches 1·5	Good	13
Ankylosis ? ..	5	Adduction	19	Slight ..	5		Fair	8
Fibrous union	10	Abduction	2				Poor	3

As might be expected, the functioual results are most often satisfactory in the younger patients, as is shown in the following table:—

Table III.—Comparative Functional Results in regard to Age.

Age 20-49				Age 49-70			
No. of Cases	Good	Fair	Poor	No. of Cases	Good	Fair	Poor
14	11	3	0	10	3	4	3

The relation of fixation to function is shown in the following extract:—

Table IV.—The Relation of Fixation to Function.

Joint Condition	Cases	Results		
		Good	Fair	Poor
Arthrodesis ..	9	9	—	—
? Arthrodesis ..	5	2	3	—
Fibrous joint ..	10	2	5	3

The nature of the incision employed does not appear to have much bearing on the question of the production of bony fixation. The relative merits of the approaches from a surgical point of view have already been considered.

In the five cases in which the head of the femur was excised on account of a painful ununited fracture of the neck, an attempt was made to effect an arthrodesis. In three cases a beef-bone peg was employed, and in the other two no special means of internal fixation were made use of. In the first three cases arthrodesis resulted, and in the other two a mobile and fairly stable joint was the result.

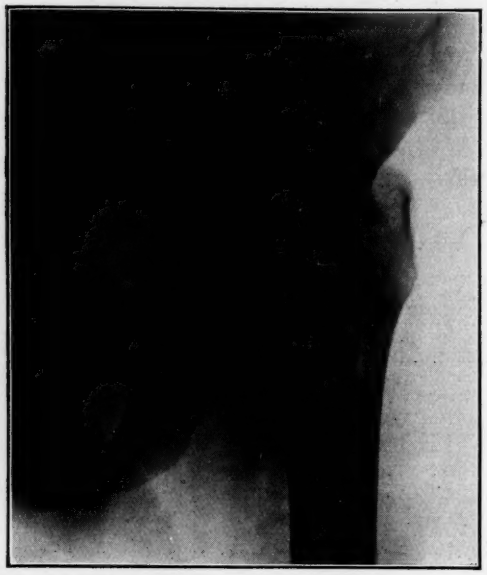

FIG. 140.—Fixation with beef peg after an old excision of head and neck of femur for a wound: X-ray nine months after operation: hip stable, function good.

One fatality occurred in the series: a case (32) operated on in September, 1923. The condition was one of long-standing monarticular osteo-arthritis of the left hip in a man of 75. The patient died nine days after operation with symptoms of uræmia. Post-mortem examination showed cystitis and infection of the kidneys. The fatal issue must be accepted as secondary to operation, but the patient was clearly unfitted for any serious operative procedure.

The Knee-joint.—In this joint the accepted opinion is that an arthrodesis resulting from an excision gives good results both with regard to relief of pain and the preservation of the use of the limb. I have carried out the operation in fourteen cases. Bony ankylosis resulted in all. In one case pain definitely persisted after operation. The patient was a man, age 30, apparently in good health. The Wassermann reaction was negative. There is firm bony ankylosis, and he is at work, but he still complains of deep pain in the region of the knee-joint two years after operation.

In two cases complaint was made that pain developed

FIG. 141.—Excision of head and neck of femur to effect a false joint in right hip (*Case* 12). The femur has been allowed to drop out, and is not stabilized against the acetabular rim as should be done, by abducting the leg.

in the ankle-joint after much walking. This appeared to be due to development of a rheumatoid change in this joint. In both cases the knee was fixed in the fully extended position, and so the ankle was put through a very full range of movement in the action of walking.

Cases of synovectomy of the knee are reported by Müller and Swett. The former quotes three cases, all of which were stated to have remained relieved from two to four years after operation, the range of movement retained being fair. Swett's records are in relation to polyarticular infections

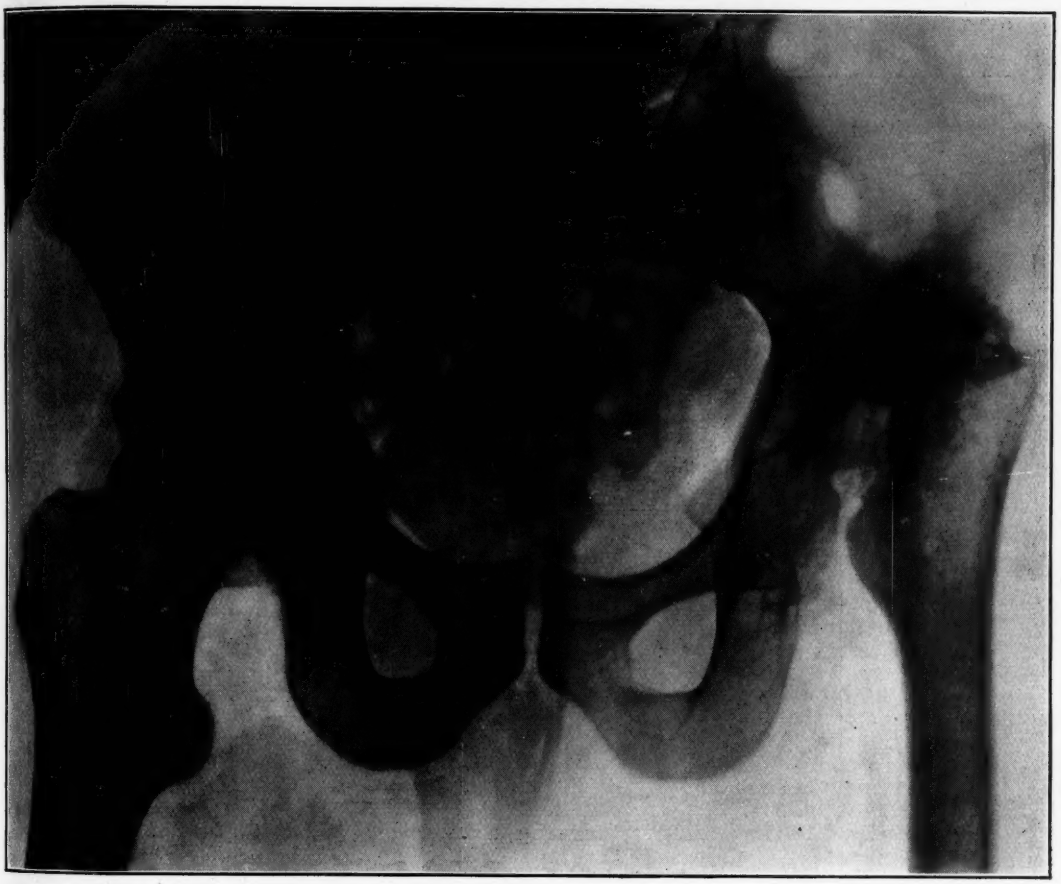

FIG. 142.—Excision of head and neck of femur for osteo-arthritis, complicating old ununited fracture: femur movable, but stabilized against rim of acetabulum (*Case* 8).

of recent origin, and therefore do not come within the scope of the present inquiry. I have carried out this operation in the last two years on four cases of hypertrophic villous synovitis. In all, the recurrent effusion and resulting disability was relieved, and a fair range of movement at the joint attained. It is, however, too early to estimate the ultimate value of the procedure in these cases.

This completes my survey of the subject as far as it can be pursued with the material at present available. I would admit that it is incomplete in

that it lacks a sufficient measure of crucial evidence. I hope, however, it may assist in clearing the ground. It should in some measure define the rôle which can be played by the surgeon in the treatment of certain cases of a common and disabling condition.

In concluding, I desire to acknowledge my great indebtedness for the numerous X rays I have had taken in the investigation of these cases. The Radiological Staff at St. Thomas's Hospital, and Dr. Tindal-Atkinson at Shepherd's Bush, have always cheerfully co-operated, however exacting my demands may have been.

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EXTRAVASATION OF URINE: WITH ESPECIAL REFERENCE TO PERI-URETHRAL ABSCESS.

By HAMILTON BAILEY and G. P. B. HUDDY, London.

During the fifteen years 1908–22, 107 cases of extravasation of urine from all causes were admitted into the London Hospital as set out in detail in the following table. There was no example of extravasation following ulceration around a urethral or ureteral calculus, nor was there a case of demonstrable perirenal extravasation following injury. As in more than half the cases the extravasation followed a peri-urethral abscess, the latter will receive major consideration in this paper.

Table Showing the Source of Extravasation and the Mortality in the 107 Cases.

Source of the Extravasation	Number of Cases	Mortality
		Per cent
Peri-urethral abscess	65	44
Traumatic rupture of urethra ..	20	20
Injury to urinary bladder	13	92
Following suprapubic puncture ..	7	57
Extravasation in infancy	1	—
Following internal urethrotomy ..	1	—
	107	

EXTRAVASATION FOLLOWING PERI-URETHRAL ABSCESS.

This condition frequently complicates urethral stricture of long standing. But stricture does not appear to be the essential factor in causation, because the stenosis in some cases is not sufficient to cause complete retention of urine, and in a few cases stricture is excluded by urethroscopic examination. The determining factor in this catastrophe appears to be a virulent infection of the mucous membrane of the deep urethra extending to the peri-urethral tissues. Some authorities, recognizing this fact, have attributed the whole condition to a spreading cellulitis. Mr. Frank Kidd,[6] however, in a series of cases, demonstrated that a fluid containing 2 per cent of urea could be isolated from the affected area.

Clinical Features.—These cases may be divided into three groups: (1) A swelling (peri-urethral abscess) has been present for a considerable period, but recently has increased in size and broken its confines; (2) Whilst straining at micturition, the patient experiences a 'sudden bursting'

in the perineum; (3) A perineal fistula (often of spontaneous origin, and following an abscess) has recently closed.

In severe and neglected cases the general symptoms may entirely mask the local condition. Thus, repeated rigors may be the leading feature of the case, or the patient is seen in delirium or coma.

In contradistinction to traumatic cases, the extravasation is not necessarily confined to those planes defined by the anatomist. It is not exceptional to find the cellular tissues of the thighs and peri-anal regions infiltrated. The probable explanation lies in the fact that the extravasated urine is infected, and suppuration breaks down anatomical barriers. Sir Benjamin Brodie stated that a black patch on the glans penis was a sign of fatal omen; of three such cases in this series, one recovered. It is generally noted that the extravasation proceeds more rapidly on one side than the other. Possibly this is due to the lateral position adopted by the patient in bed, or, as seems more probable, the urethral wall perforates upon the lateral aspect (see *Fig.* 143).

Differential Diagnosis.—The diagnosis is usually obvious.

General.—The severity of the general signs may, on occasion, mask the local condition; for instance, a case with repeated rigors has been confounded with malaria. Again, if the outstanding feature is delirium, a diagnosis of pneumonia or typhoid may be made, as recorded by Wolfer.

Local.—Turning to the local signs, difficulties in diagnosis are occasionally encountered; notably the scrotal œdema may be due to other causes, e.g., anasarca consequent upon a failing heart, or spreading cellulitis from an ischiorectal abscess. Each of these conditions, simulating extravasation, has been recently observed.

Mortality.—The mortality of this condition is exceedingly high. In this series 43 per cent died. The principal causes are septicæmia and uræmia; frequently the two go hand-in-hand.

Treatment.—The two great indications in treatment are to mitigate the blood infection and combat the uræmia. The first is carried out by making adequate incisions to relieve tension and admit of the free escape of urine and inflammatory products.

If, as is commonly the case, the patient exhibits uræmic symptoms, the stricture is probably a tight one, and the uræmia is due to retention reacting upon kidneys already seriously damaged by back-pressure, which has extended over a long period. In these cases it is of the utmost importance to relieve the condition by draining the bladder. It is not enough to make incisions into the inflamed area, or even to divide the stricture in addition. The bladder must be drained.

We will now examine the various methods which have been employed in dealing with this condition, and discuss their relative merits. They are: (1) *Multiple incisions only*; (2) *Multiple incisions combined with suprapubic cystotomy*; (3) *Multiple incisions combined with perineal cystotomy.*

1. Multiple Incisions, including Simple Incision of the Peri-urethral Abscess.—For very many years this has been the method most generally adopted. The results are not always satisfactory, for the following reasons:—

In order to treat the condition radically, it is essential to relieve the retention at the earliest possible moment. Once the intra-urethral pressure behind the stricture is zero, the infected urine ceases to be extravasated, and attention can be directed to the cellulitis which invariably follows in its wake.

It might be argued that a peri-urethral abscess is an attempt by nature to perform external urethrotomy, and therefore by incision of the abscess 'the object of surgery' (i.e., to aid nature) is achieved. Unfortunately this simple measure is not always effective; moreover, in some cases there is very little pus or urine to evacuate.

In two recent cases it was noted that wide incision of the abscess did not open the urethra. The condition can best be illustrated by a diagram (*Fig.* 143). The effectiveness of this treatment is to a large extent governed by the size of the opening **B**. Since the opening is usually small and laterally placed, more thorough treatment is indicated. Simple incision should be reserved for desperate cases.

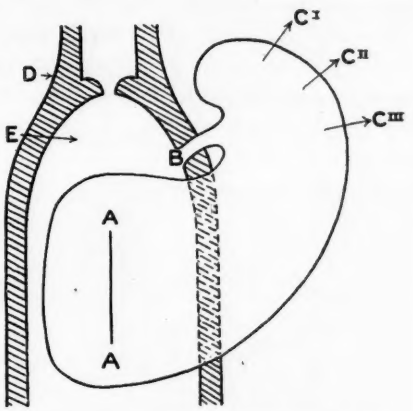

FIG. 143.—Diagram illustrating wide incision of abscess without opening urethra. A–A is an incision into the peri-urethral abscess which communicates with the urethra through a small lateral orifice (B) behind the stricture. $C^{I}C^{II}C^{III}$ is that part of the abscess wall which has given way, and through which urine and pus are extravasating. D, Stricture. E, Dilated urethra.

2. MULTIPLE INCISIONS COMBINED WITH SUPRAPUBIC CYSTOTOMY.—This is strongly recommended by Wolfer. The method has the very obvious disadvantage that the cystotomy incision of necessity traverses the infected superficial planes, and thus infection may be carried to the cave of Retzius. If this occurs there is the danger of deep pelvic cellulitis, a very grave complication which proved fatal in one recent case under observation. Further, if the bladder is much distended and the patient uræmic, the immediate effect of a suprapubic cystotomy will be to depress the renal efficiency still further and thus very possibly hasten a fatal termination.

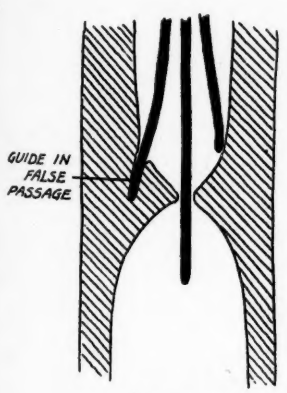

FIG. 144.—'Faggot' method of introduction of bougies.

3. MULTIPLE INCISIONS COMBINED WITH PERINEAL CYSTOTOMY.—This appears to be the method of choice, and therefore will be set out in detail.

Preliminary Urethroscopy to ascertain the site and estimate the calibre of the stricture if one is present.

The Urethra is Washed out, and novocain is instilled. The additional injection of methylene blue into the urethra in order that the mucous membrane can be more readily recognized during the perineal stage of the operation has been found to be disappointing—for necrotic tissues do not readily take up the stain.

An Attempt is made to pass a Bougie into the Bladder.—Great gentleness is exercised, for the urethra, being inflamed, may easily be perforated.

However, it is usually possible to pass a No. 3 or No. 4 French. In the absence of an instrument by which the bougie can be passed under direct vision, the 'faggot method' (*Fig.* 144) of introduction is of distinct value. The introduction of a guide simplifies the subsequent stages of the operation. If the bougie has been passed, it should be fixed in position. The patient is now anæsthetized. Spinal stovaine is indicated, for the uræmic condition of the patient renders a general anæsthetic dangerous.

a. If the bougie has failed to pass through the stricture: Wheelhouse's operation should be performed.

b. A bougie has been passed (which will be found possible in the majority of cases): The patient is now placed in the lithotomy position, and a sand-bag placed under the scrotum to exaggerate effectively this position. Lane's tissue forceps are clipped upon the most dependent part of the infiltrated scrotum. These serve as scrotal retractors. By this method the scrotum is pulled up and the perineum is clearly exposed to view. Towels having been arranged, an incision is made from the base of the scrotum to within $\frac{1}{2}$ in. of the anal verge, keeping strictly to the middle line. The tissues in this region being extensively infiltrated, it is usual to find that one has to proceed to a depth of $\frac{3}{4}$ in. or more before the abscess is reached. Urine and pus then escape, usually under considerable pressure.

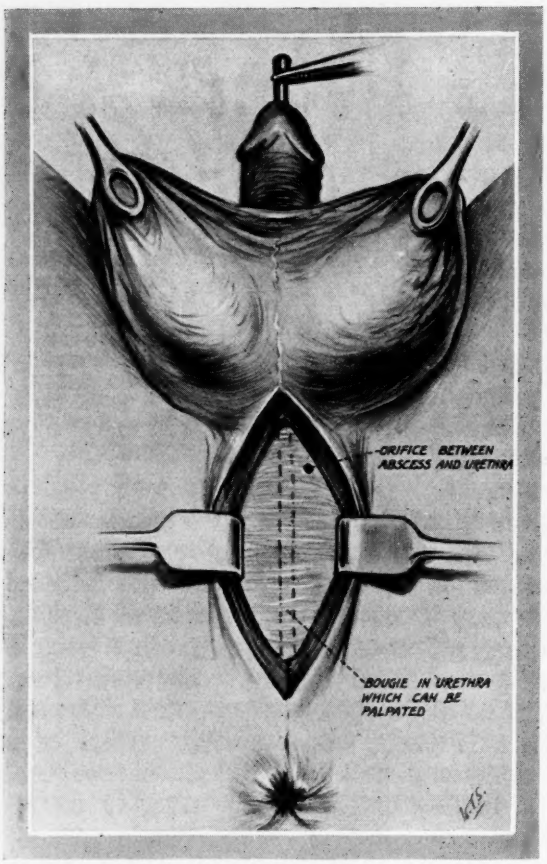

FIG. 145.—Showing position of bougie in the urethra.

A finger is now passed into the wound, and the bougie within the urethra (*Fig.* 145) sought for by palpation. Retractors are then placed in either side of the wound, and the urethra is inspected. A head light is very useful at this stage. The breach in the continuity of the urethra can sometimes be seen. There was a hole admitting a probe in the lateral aspect of the necrotic urethra in two cases recently observed. The floor of the urethra is incised and the edges are retracted. The left index finger is passed into the dilated urethra, with the pulp against the bougie. The finger is thus guided into the bladder. A large coudé catheter is then passed through the incision along the index finger into the bladder, and secured to one side of the wound with a stitch.

It is inadvisable to withdraw more than one pint of urine if the bladder is greatly distended. The residue is evacuated at intervals of four hours.

Drainage of the Cellular Tissues (*Fig.* 146).—The left forefinger is now passed through the perineal wound, upwards and outwards, clearing the crus penis, and made to protrude subcutaneously above and to the outer side of the symphysis pubis (*see Fig.* 147); the skin is then incised over the finger, and long blunt-nosed forceps retrace the path and emerge in the perineal wound. The jaws are opened and grasp a $\frac{1}{4}$-in. drainage tube, previously perforated, which is then pulled up and fixed by a stitch. This procedure is repeated on the opposite side.

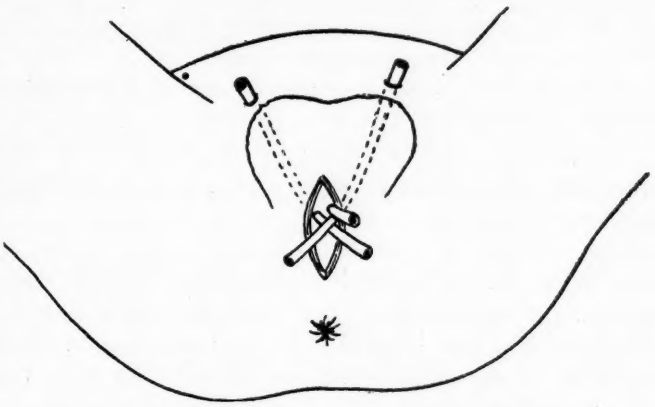

FIG. 146.—Method of drainage (after Hartmann).

Incisions into the Infiltrated Tissues.—In contrast to the older methods, fewer but larger incisions are recommended. There is a tendency, on account of the infiltration, for the incisions to be too superficial; they must be of sufficient depth to penetrate the limiting fasciæ.

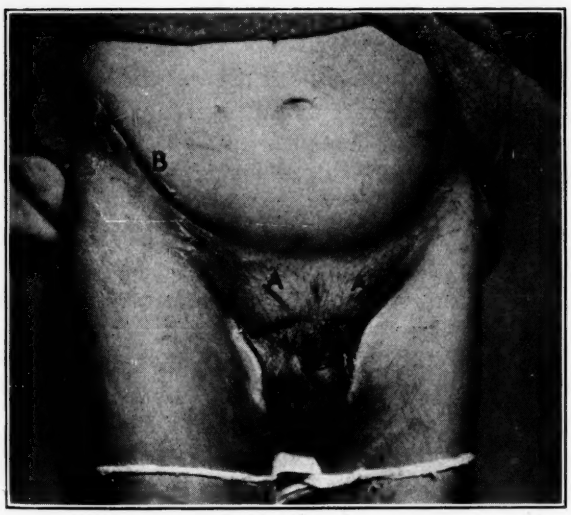

FIG. 147.—Patient convalescent from peri-urethral abscess with extravasation. A, A. Site of subcutaneous tubes referred to in text; B, A long incision into the infiltrated tissues.

Injections of Hydrogen Peroxide.—It has been shown that anaerobic organisms are largely responsible for the spreading cellulitis in these cases (Jungano). As oxygen is inimical to these organisms, hydrogen peroxide is injected into the subcutaneous tissues around the incisions by means of a Crile's anoci-association syringe, fitted with an angular needle.

Dressings.—Moist dressings of eusol are applied over the abdominal wall, perineum, and scrotum; these are covered over by packing towels, and the whole is secured by a T-shaped bandage.

After-treatment.—During the first twenty-four hours the patient is encouraged to drink as much fluid as possible; rigors are usual during this

period, and are most successfully combated by hot gin and quinine. The catheter is removed at the end of forty-eight hours. Every four hours all the wounds are irrigated with eusol through a Higginson's syringe, after hydrogen peroxide has been instilled for a few minutes. At the fourth day shortening of the tubes should be commenced. As soon as the general condition permits, sitz baths are instituted.

Drugs.—Acid sodium phosphate and hexamine, combined with tincture of hyoscyamus, are given in liberal doses.

Residual Abscess.—This is frequently seen in the flank just above the anterior superior iliac spine. Under gas anæsthetic the abscess should be freely opened.

When the infection has subsided, which is usually in about three to four weeks, the treatment of the perineal fistula should receive attention. If the stricture has not been divided, an internal urethrotomy with insertion of a catheter is an effective method of dealing with the condition and hastening the closure of the wound. Occasionally it may be possible simply to dilate the stricture with bougies.

The patient should not be discharged until the fistula is closed, and the stricture must then be dilated regularly.

EXTRAVASATION FROM OTHER CAUSES.

Ruptured Urethra.—Under the title of ruptured urethra there are included two entirely distinct clinical entities:—

a. The first consists of the classical cases due to a fall astride and resulting in a complete or incomplete tear of the bulbous urethra. Of 47 cases of ruptured urethra of this type admitted to the London Hospital during the period under consideration, only 11 were complicated by extravasation of urine.

b. This comprises those cases in which the urethra is torn above the anterior triangular ligament—the morphological bony pelvis. There were 9 examples in this series. This variety is a direct complication of fractured pelvis, and the extravasation occurs into the cave of Retzius.

The differential diagnosis between an intrapelvic rupture of the urethra and an extraperitoneal tear of the bladder is usually a matter of profound difficulty. The diagnosis in the majority of cases is uncertain until a suprapubic incision has been made. Even then some difficulty may be encountered in determining the exact site of the lesion amidst the blood-stained effusion. There is, however, one guiding rule: if the bladder is even moderately distended, the lesion must be situated below the vesical sphincter.

Injury to the Urinary Bladder.—Extraperitoneal, 5; Intraperitoneal, 4; Extra- and intraperitoneal, 4; Total, 13. Nine of these followed an abdominal contusion or a fractured pelvis; two were consequent upon catheterization and irrigation of a dilated atrophic bladder secondary to enlarged prostate: at necropsy the bladder showed a perforation at the fundus in both instances. There was one example of extravasation following an injury to the bladder during an operation for the relief of strangulated

femoral hernia. Lastly, there was a case following normal parturition, and this is so exceptional as to warrant some reference to the details.

A primipara, age 28, was confined five days previously and delivered, without forceps, of a healthy child. On admission the condition was desperate. There was great abdominal distention and fæcal vomiting. Laparotomy was immediately performed, the peritoneal cavity being drained through a sub-umbilical incision. The patient died a few hours later.

A necropsy showed general peritonitis due to extra- and intraperitoneal tears of the posteriar part of the fundus of the bladder ; the surrounding mucosa was injected and sloughing. There was a uterine tear limited to the cervix.

Extravasation following Suprapubic Puncture.—Seven cases followed aspiration of the bladder for relief of acute retention.

At operation, in two of the most recent examples of extravasation from this cause, a puncture of the vesical wall through which urine was escaping could be clearly seen. Therefore simple suprapubic puncture is a method not devoid of danger. It is obvious that, unless the cause of the retention has been removed before the bladder again becomes tense, there is always a risk of leakage occurring at the site of the puncture. If urine thus extravasated is infected, pelvic cellulitis must ensue. The introduction of a catheter through a suprapubic trocar of suitable dimensions obviates this complication, for the intravesical pressure remains minimal. There was no case of extravasation in this series following the latter method.

Extravasation of Urine in Infancy.—In this series there is but a solitary example of this very rare condition.

A male, age 6 weeks, was admitted with acute retention and extravasation into the scrotum and far up the abdominal wall. Temperature 104°. External urethrotomy was performed, and combined with multiple incisions. The child died.

A necropsy showed a purulent external urethrotomy wound leading into a lacerated urethra and communicating with a peri-urethral abscess in front of the triangular ligament. There was gangrenous cellulitis of penis, scrotum, and cave of Retzius, and an abscess in the right lobe of the prostate. The meatus was of normal calibre, and there was no phimosis. The bladder was distended and hypertrophied, and the kidneys showed parenchymatous degeneration and pin-head abscesses. Slight seropurulent leptomeningitis in the Sylvian fissure and over the right temporal lobe was associated with cerebral softening and embolism of the right cerebral artery.

The cause of the extravasation in this extremely interesting condition was obscured at necropsy by the purulent external urethrotomy wound, which precluded the possibility of a precise diagnosis. As there was no evidence of meatal stenosis or of urethral calculus, it seems probable that this was a case of congenital stricture of the deep urethra.

Extravasation following Internal Urethrotomy.—This is a very rare complication of the operation. The danger would appear to lie in the passage of the pilot into a false passage.

A greengrocer, age 53, had suffered for some months with dysuria, culminating in strangury ; for twenty-four hours before admission he had absolute retention, which was relieved by a hot bath. Four days later, under gas and novocain, an internal urethrotomy was performed, and was followed two days later by a typical extravasation. The treatment consisted of multiple incisions and the insertion of a silver catheter. The patient sank, and died in coma.

Necropsy revealed cellulitis involving the penis, scrotum, and abdominal wall. There was a stricture 1·7 cm. long in the bulbous urethra. A false passage led into a purulent sinus at the side of the stricture, and extension of the sinus passed upwards along the corpora cavernosa and communicated with a large abscess of the left lobe of the prostate.

After completing the foregoing, and being desirous of finding the exact source of Brodie's observation that a black patch on the glans penis was a harbinger of death (which Mansell Moullin referred to in his text-book of 1891), we consulted the works of Sir Benjamin Brodie. So full of interest are Brodie's observations on this subject that we beg leave to quote verbatim from his *Diseases of the Urinary Organs*, 4th edition, 1849.

"Sometimes a black spot is seen on the glans penis: an almost fatal symptom, indicating that the whole of the corpus spongiosum is infiltrated with urine. . . .

"But the danger from the effusion of urine is not the same in all cases. In the majority the effusion takes place in front of the triangular fascia of the perineum, or else the fascia gives way and allows the urine to pass forward to the superficial parts instead of penetrating to the deep-seated; and under these circumstances life may generally be preserved by the prompt interference of the surgeon. In a very few cases the effusion extends into the loose cellular membrane which surrounds the bladder, and the patient's condition is hopeless.

"Where the urethra has given way behind the stricture, and the urine has become effused into the cellular texture, very prompt and vigorous measures are necessary: delay is fatal. I remember the time when five out of six of the patients in whom this mischief took place perished; but now, from the more active treatment employed under the hands of a well-informed surgeon, the great majority recover.

"I have already mentioned that the effusion of the urine is followed by a relaxation of the stricture. You will probably now be able to introduce a catgut, or some other bougie (a catgut one is to be preferred), through the stricture into the bladder. If you can do so, it is so much the better. Introduce the bougie; let the patient be held in the position in which you would place him for lithotomy; make an incision in the perineum; feel for the catgut bougie, and make an incision on it; of course, you make an opening in the urethra. Through this opening, the catgut bougie serving you as a director, introduce a short gum catheter from the wound in the perineum into the bladder. You will generally find, although the effusion of urine has taken place, that there is still a large quantity of urine left in the bladder. Of course, it is drawn off by the catheter, and the bladder is emptied. Allow the catheter, however, to remain in the wound and in the bladder. Then make extensive scarifications or incisions through the skin, wherever the urine has been effused underneath, and let these incisions extend to the sloughs of the cellular membrane."

Thus, over three-quarters of a century ago Brodie devised a technique which reduced the mortality of this condition from "five out of six" to "a recovery of the majority".

Under modern condition and advantages, would not the adoption of the

basic principles of the great pre-Listerian master improve the prognosis of this, the commonest variety of urinary extravasation?

We beg to record our thanks to the surgeons of the London Hospital, and particularly to the director of the Genito-Urinary Department—Mr. Hugh Lett—for his invaluable help in the preparation of this article.

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THE MEDIAN EXTRAPERITONEAL ROUTE TO THE URETER.

By K. W. MONSARRAT, Liverpool.

The routes commonly employed in ureteral lithotomy are: (1) The lumbar; (2) The inguinal; (3) The transperitoneal. It may be confidently stated that the sacral, perineal, vaginal, and rectal routes are not now followed.

1. The lumbar route has a limited use in those cases where a calculus is lodged in the renal end of the ureter, and the incision and subsequent steps of the operation are as for a pyelotomy.

2. The inguinal operation is either a muscle-cutting or a muscle-splitting operation or a combination of these. It gives excellent access to the calculus which is arrested about the pelvic brim, but indifferent access to one in the depth of the pelvis. If a calculus cannot be milked upwards, the suture of the ureteral wound is difficult.

3. For the transperitoneal route the advantage of palpation of the opposite kidney and ureter was claimed, but no longer carries weight. While the route has the advantage of being short and direct, it is generally felt by surgeons to be undesirable. It inevitably adds to post-operative discomfort, and is attended by some risk of infection.

I am aware of the combination of a transperitoneal exploration and an extraperitoneal exposure, but have no experience of its usefulness.

I wish to testify to the great technical advantages of a median suprapubic incision down to the peritoneum, followed by extraperitoneal exposure of the ureter by peritoneal displacement. The steps of the operation are as follows: An incision is made from umbilicus to pubis, the aponeurosis is divided to the same extent, the recti are bluntly separated, and the extraperitoneal plane is reached. If the calculus is in the right ureter, separation of the peritoneum proceeds on that side towards the iliac fossa, continued round the pelvic basin until the common iliac bifurcation is reached, when the ureter is found and comes off the vessel with the peritoneum. A large broad-bladed retractor is then inserted, and displaces inwards the peritoneal sac and its contents. The ureter is then traced to the point of impaction of the calculus, and this is displaced as may be thought desirable, and removed. After suture of the ureteral wound a stab wound is made through the abdominal wall in the right iliac fossa through which a half tube passes towards the site of the ureteral mend. Retractors are then removed, the peritoneum falls back into place, and the median wound is sutured throughout its length.

Apart from a somewhat similar procedure for cases of bladder resection, I first employed this method for the removal of a ureteral stone in the following case: On Nov. 11, 1920, I removed an adenomatous prostate by

suprapubic enucleation from a patient 57 years of age. He was a healthy man of powerful physique, weighing some 16 stone. On Dec. 6, 1921, I removed a calculus from his bladder and another from the lower end of his left ureter. The bladder was reopened through his suprapubic scar and the vesical calculus removed. By peritoneal stripping between bladder and left pelvic wall the ureter was exposed and the calculus here removed. I had expected to be able to remove it through the left ureteral orifice from inside the bladder, but this proved impossible. He left the home healed four and a half weeks later.

I have used the same procedure on many occasions since then, the last example being the following: A male patient, age 32, an engineer by occupation, was admitted to the Northern Hospital on Feb. 16, 1924, complaining of blood in the water and pain in the right side. He stated that the first attack of pain occurred in August, 1921, and that he then noticed blood in the urine. He had had several attacks of the same kind since.

Radiographic report: "There is a shadow in the pelvic region on the right side in the line of the ureter which may be a calculus, but its long axis is not in the direction of the ureter." A fair number of red blood-cells were present in the centrifugalized urine deposit. The right kidney was not palpable. Although the radiologist's report was not definite, the diagnosis of ureteral calculus was considered positive.

On Feb. 26 an incision was made from umbilicus to pubis. The extraperitoneal plane was opened up below, and the peritoneum stripped from the right pelvic wall until the ureter was reached. The calculus was easily found and displaced upwards, the ureter was incised, and the calculus removed. The ureter was explored with catheter upwards and downwards, and the wound then sutured with catgut 000. A stab wound was made through the abdominal wall an inch inside the anterior superior spine, and a half tube passed to the site of the ureteral wound. The retractors were then removed, and the suprapubic wound was sutured with interrupted catgut stitches and supporting through-and-through stitches of silkworm gut.

The drainage tube was removed in forty-eight hours, the dressing being dry. He was discharged from hospital eighteen days after operation.

VISITS TO SURGICAL CLINICS AT HOME AND ABROAD.

THE CLINIC OF PIERRE DUVAL, PARIS.

A SMALL group of surgeons visited the clinic of Professor Pierre Duval in Paris recently. This is a record of the impression made upon them of what they saw there. The time spent in the clinic was brief, so that the insight into the activities engaged in by the workers of the institution was necessarily limited. L'Hôpital de Vaugirard contains nearly 200 beds, all of which are under the direction of the Professor. We have no entity corresponding to it in this country; it is not comparable with the surgical division of one of our hospitals, as will be seen from what follows: it is described as a 'clinique thérapeutique chirurgicale', a quite untranslatable expression, as it implies a definite unit such as is unknown over here. The staff is a large one. There are an assistant professor and two assistant surgeons (chefs de clinique chirurgien), one physician, two foreign surgical assistants, three surgical internes, and ten externes. These are members of the ordinary surgical service; and in addition there are a urologist, gynæcologist, oto-rhino-laryngologist, oculist, dentist, and two radiographers, whilst in the special department for gastro-enterology there are three physicians. There are two chemical laboratories and also a combined pathological and bacteriological laboratory, all of which have their own adequate staffs.

The hospital receives a large grant from public funds, and the Professor is allowed great latitude, not only in the expenditure of this money, but in the plan of administration of his clinic. There is plenty of room for individual expression, and it seems the object of the State to foster originality by freeing the Professor from the hampering shackles of State control. An outstanding feature of the clinic is a vitality of outlook and an all-pervading spirit of investigation. Research takes a more prominent part than undergraduate teaching, though this is not lost sight of by any means. Professor Duval holds that prolonged undergraduate teaching is mentally sterilizing, and that after a number of years only advanced teaching should be required of the head of a large clinic. He therefore relegates undergraduate teaching to his staff, confining himself to post-graduate and advanced instruction. At present he is concerned particularly with diseases of the digestive tract, and it is interesting to see how the problems arising out of this study are tackled. The physicians, radiographers, and pathologists all see the patients clinically with him, whilst they all witness the radiographic examination and the operations performed, should such be decided upon. No case is radiographed without the Professor being present. In this clinic there is no such thing as one

member of the team falling behind in his knowledge of his colleagues' special departments. Nothing but good can come from such a system. It makes co-ordination a real thing, but it is necessarily exacting in the time and energy demanded from all the members of the clinic.

A great deal of research is being carried on in the radiographic appearances of affections of the duodenum and gall-bladder. A wonderful selection of photographs was exhibited. Pierre Duval claims that he can diagnose 40 per cent of gall-stones by direct radiography, and another 40 per cent from indirect radiographic evidence. From the perfection of technique shown to the visitors, this is easily credible. M. Béclère, the radiographer, has

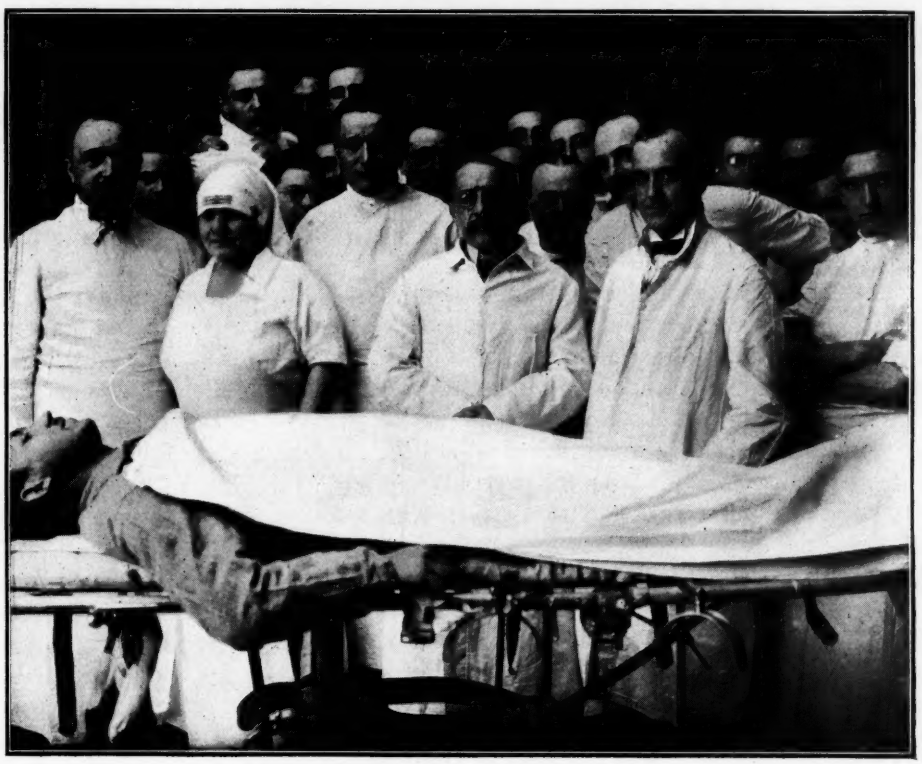

Fig. 148.

invented a very ingenious apparatus by which a number of films of about half-plate size can be exposed in rapid succession, up to thirty, in the minute. The films in separate holders are loaded in the apparatus used for screening in the erect position. The opaque meal is watched as it passes into the duodenum, and at any moment a photograph can be taken without moving either the patient or screen. In studying the duodenum and gall-bladder great use is made of lateral views. Some radiographs of chronic duodenal ileus due to obstruction by the superior mesenteric artery were shown, and it was explained how such obstruction, present in the erect position, is relieved when the patient lies prone. The many points by which gall-stones render

their presence evident were gone into, such as the movement of the shadows with change of position of the patient, their situation in profile view in relation to the spine, the distortion of or dragging on the duodenum.

Some interesting skiagrams illustrating the surgical treatment of Pott's fracture were demonstrated, and the method employed was explained. Immediately the patient is admitted, a spinal anæsthetic is given and reduction attempted on the X-ray couch. Should it be successful, a plaster cast is applied; but if all efforts are ineffective, operation is proceeded with. It consists in the fixation of the fragments in proper position by means of screws. An original method of photographing the elbow or knee-joint in a flexed position was demonstrated. The limb is bent over an earthenware jar, round which is wrapped the X-ray film. The tube, by a clever removable projection apparatus, is centred accurately over the joint space, and the skiagram taken. Photographs were exhibited which clearly proved that in this way the joint space in the knee appears much larger than by the usual method, whilst by this technique alone can certain loose bodies in the joint be detected.

A tour of the laboratories was made, and in the lecture room was seen a simple and cheap apparatus for projecting diagrams and solid objects on the screen (episcope).

The next day several operations were witnessed. The operation theatre itself is a large room with walls green to diminish eye-strain. It contains literally nothing beyond an operation table, anæsthetist's stool, anæsthetist's table, and instrument and dressing tables; not even a gallery for spectators. There are no rows of bottles on shelves, or apparatus of any other kind. The walls are perfectly smooth. The actual operative technique is interesting from many points of view. For abdominal work, local and conduction anæsthesia are not used. The Professor has found the incidence of lung complications after these methods as great as, if not greater than, after inhalation anæsthesia. The Clover apparatus is used for the administration of ether. The operator and his two assistants wash and dress in a neighbouring room. The patient is strapped to the table. The instruments in a metal container are sterilized by dry heat, a separate set for each case. They are placed in their container on the operator's table. He selects and handles his own instruments, whilst ligatures are looked after by his assistant, who has them on his own table. Behind the instruments are placed the drums containing the dressings; their completely detachable lids which envelop the whole drum are removed by the sister. The operator helps himself to towels and swabs. No nurse is washed up to take part in the operation. The nursing staff simply convey to the operator instruments or dressings in sterilized containers. Non-absorbable suture material is used for most intestinal anastomoses and for the stomach. Catgut is only used within the abdomen for septic cases. It is employed for suturing the muscles of the abdominal wall, but not for the peritoneum. Access to the operation area in the abdomen is gained by the free use of large retractors. Thus, when operating upon the upper abdomen, a large Doyen retractor is inserted in the upper angle of the wound. All sewing is done by means of Reverdin needles of different sizes: this makes for rapid work with a perfectly trained assistant.

The first operation was for a duodenal ulcer situated at some distance from the pylorus. A posterior gastrojejunostomy was performed without clamps, and the pylorus closed by a single encircling suture. M. Duval says he has met with but one gastrojejunal ulcer, and attributes this to the fact that he does not use clamps.

The second patient had a number of adhesions around the duodenum, and was described as being a case of simple periduodenitis due to disease of the gall-bladder without stones. The adhesions were separated and cholecystectomy performed. The gall-bladder was removed from the neck towards the fundus. No drainage was provided. The operator explained that only in 10 per cent of cases was it possible to close the abdomen without drainage, the ability to make a proper peritoneal covering for the stump of the cystic duct determining the possibility of doing this.

The third case had been diagnosed as one of simple periduodenitis, but it proved to be chronic duodenal ileus. This made the thirty-second case of the kind upon whom the Professor had operated. A duodenojejunostomy was performed.

The last case was gynæcological in nature, an ectopic gestation. The affected tube was removed. Catgut was used in the abdomen in this patient.

The speed at which technique is carried out in this clinic can be gathered from the fact that these four operations were performed in two hours and ten minutes, although there were considerable intervals between them, the same anæsthetist acting in each case. The character of the operating was to perform the essential steps in the shortest possible time and return the patient to bed, neglecting certain niceties of technique upon which stress is laid by some surgeons. The theatre was kept unusually hot, with the idea apparently of diminishing the risk of subsequent bronchial affections. For the first few days after the operation the patients are kept in separate cubicles before being returned to the general wards. The perfection of organization of the whole hospital is illustrated by a small point. Each patient has an electric bell-push. Should he ring for help a red lamp glows outside his cubicle, and remains alight until extinguished by the answering nurse.

One came away from the clinic impressed with the dynamic atmosphere pervading it, with a feeling that advance in knowledge must proceed from such a system, and convinced of the essentially sound policy adopted by the State of granting an unusual liberty of action to its professors, in the belief that only in this way can real progress be made.

SHORT NOTES OF RARE OR OBSCURE CASES

AN OBSCURE CASE DUE TO CALCULUS IN THE PELVIS OF AN ECTOPIC KIDNEY.

By HUGH REID, Liverpool.

The case was under the care of Mr. Thelwall Thomas at the Royal Infirmary, Liverpool, and seen by the writer as surgical registrar. The patient is a male, age 28.

History.—He gave a history of attacks of pain in the left lower lumbar region for the last three years. This was accompanied by frequency of micturition and the passage of dark-coloured urine. Lately the attacks had been becoming more frequent and severe, and the intervals of relief shorter. The pain was of a cutting nature, starting in the left lumbosacral region and shooting towards the groin. It lasted about twelve hours, and was followed by what the patient thought was blood in the urine. At the same time he suffered from pain in the suprapubic region, which passed some way down the penis.

On Admission, in November, 1923, the man looked healthy. He lay easily in bed; the abdomen moved normally with respiration; no abnormal swellings, or rigidity or tenderness, were detected. The urine showed a few blood-cells, but no crystals. Pus-cells and epithelial cells were seen in direct films. Staphylococci were grown on culture.

The X-ray report (by Dr. R. E. Roberts) was: "Stone in bladder" (*see Fig.* 149).

On Nov. 29 Mr. Thomas passed a lithotrite, but no stone was felt. A sound was then passed and a careful exploration of the bladder made, without result. A cystoscope was substituted for the sound, but nothing abnormal was seen in the bladder. The patient was sent away for another skiagram.

On Dec. 4 a further X-ray report stated: "Same shadow in practically the same place, but rotated on its axis. The only other two possibilities are (1) calcareous gland of unusual appearance, or (2) stone in a much distorted ureter. The shadow is not so clear cut as one would expect in the case of a ureter stone. The whole thing is atypical".

On Dec. 6 cystoscopy showed pus coming from the left ureteral orifice. The right ureteral orifice was normal. From this it was decided that the condition was due to stone low down in a much dilated ureter.

Operation, Dec. 12, by Mr. Thomas.—Split muscle incision over left iliac fossa. Ureter not found. The kidney was then discovered to be placed

entirely below the brim of the bony pelvis. The organ could not be brought out of its bed through the wound. Renal vessels were arising from bifurcation of common iliac artery. Part of the kidney substance and the renal pelvis were incised, and a typical calcium oxalate stone was removed. The renal pelvis was sutured, and the wound closed with split rubber drainage tube down to the kidney.

On Dec. 26 the patient was discharged after a normal convalescence. The specimen measured $1\frac{1}{10}$ in. × $\frac{4}{5}$ in., and weighed 94 gr.; it was oval in

FIG. 149.—Calculus in pelvis of ectopic kidney.

shape, pale brownish yellow in colour, and the surface was covered by sharp glistening crystals.

A review of the literature of ectopic kidneys is given by Dorland[1] in 1911, and nineteen cases are reported by Judd[2] in 1919, in one of which stones in the pelvis and calices of a pelvic kidney were discovered.

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AN ABNORMAL FIRST RIB FORMING A SUPRACLAVICULAR TUMOUR.

By C. HAMILTON WHITEFORD, Plymouth.

The patient is a girl, age 3¼ years. The mother first noticed a 'lump' in the right side of the neck when the child was two years old. One inch above the centre of the right clavicle there is a tumour which projects the skin. On palpation there is found, immediately beneath the skin, a curved, fixed body of the shape and consistence of a rib. There is no pulsation, and nothing resembling blood-vessels or nerves can be felt between the tumour and the skin. There are no symptoms, and the shoulder movements are normal. No abnormality is visible or palpable in the left side of the neck. The skiagram (taken with the child lying on her back on the plate) shows that the first dorsal vertebra has, on its left side, a normal first rib, but on its right side a rib which appears as a horizontal straight bone 1½ inches in length (*Fig.* 150). Actually this rib is much longer, and curved from behind forwards.

Fig. 150.—Girl, age 3¼, with an abnormal first rib. A, Curved lead wire to mark projection beneath skin.

A palpable and visible supraclavicular tumour formed by a first dorsal rib appears to be a rare abnormality. The mother, who had been urged at a hospital to have the bone removed at once, " to prevent paralysis of the arm ", was advised that it would be time enough to think of an operation if pain or weakness should occur in the arm, and that such symptoms might never appear.

ACUTE COLIC INTUSSUSCEPTION IN A CHILD.

By W. E. TANNER, London.

The patient, a girl, age 2 years and 9 months, was admitted to hospital on March 30, 1924. She was an artificially-fed baby, and had pneumonia when one year old. Her general health was good, and she is a strong, healthy child.

At 9 a.m. on March 27 she fell down eight stairs. She was apparently uninjured, and the bowels were open normally during the course of the

morning. She was quite well until 1 p.m., when she refused her dinner and complained of pain in the lower abdomen. She was put to bed and went to sleep for half an hour. She woke up screaming, with violent abdominal pain which lasted for a quarter of an hour, but no vomiting. The pain continued for the rest of the day, with short periods of quiet. During the night the pain continued, and she kept asking for the chamber, but with no result. Tenesmus was marked, and the legs were drawn up on the abdomen.

On March 28 she seemed better, but was cross, and demanded to be nursed all day. The bowels were not open, and in the evening she had more pain and was taken to a doctor. She was given medicine, following which she vomited, and the mother said there was blood in the vomit. She refused food and drink all day, and at night the pain became much worse, with tenesmus. A little blood and mucus was passed. On March 29 the patient was easier in the morning but drowsy all day. The pain was not so severe, and there were long intervals of freedom. The bowels were not opened, and at night the pain became worse, with frequent vomiting and tenesmus. On March 30 the pain was worse in the morning, and not relieved by a hot bath. The mother was frightened by a 'peculiar look in the child's eyes', and, after consulting her doctor, brought the child to hospital.

On admission, temperature was 97°, pulse 90, respirations 30. The child looked ill and drawn. There was marked general distention of the abdomen, and a hard, sausage-like tumour was felt in the left iliac fossa. On rectal examination, an intussusception could be felt, just within reach of the finger. On withdrawing the finger from the rectum, a gush of blood and mucus followed.

Operation was performed on March 30 at 2.30 p.m.: right paramedian laparotomy. Blood-stained fluid escaped from the peritoneal cavity. The intussusception was reduced by gentle pressure from below. On reduction it was seen that it was colic, and had commenced at the splenic flexure of the colon. No polyp or other abnormality was found to account for its occurrence. The pelvic colon was elongated, and the descending colon had a complete mesentery and was freely movable. The wound was closed in layers. The patient made an uninterrupted recovery.

Acute colic intussusception is comparatively rare. In Perrin and Lindsay's[1] series it formed 5·6 per cent of 335 cases. All the idiopathic cases occurred before the seventh year. In my own series of 30, this is the first example of an acute colic intussusception. The length of the history, seventy-four hours, is of interest. In Perrin and Lindsay's series the average length was thirty-three hours. Was the accident responsible for the sequence of events? This appears to have been as follows: Elongation and distention of the pelvic and descending colon; spasm of the distal half of the transverse colon as far as the splenic flexure; irregular peristalsis; formation of an intussusception at the splenic flexure, a fixed portion of the bowel, which may have been damaged as a result of the fall downstairs.

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REVIEWS AND NOTICES OF BOOKS.

Chronic Intestinal Stasis (Arbuthnot Lane's Disease): A Radiological Study. By ALFRED C. JORDAN, C.B.E., M.D. (Camb.), M.R.C.P. (Lond.), Corresponding Foreign Member, Belgian Royal Academy of Medicine. 4to. Pp. 230 + xi, illustrated. 1923. London: Oxford Medical Publications. 25s. net.

CHRONIC intestinal stasis is here dealt with partly from the point of view of the radiologist, though the subject matter is by no means confined to radiological considerations. The author outlines the views held by Sir W. Arbuthnot Lane on the alimentary tract, and attempts to correlate them with the X-ray appearances of the opaque meal and enema in health and disease; the result is not always a happy one, as he frequently makes dogmatic statements upon subjects on which even his extensive but specialized experience can hardly support an authoritative opinion. It is, in fact, impossible to apply the ordinary standards of criticism to this work, since it forms, not so much a text-book, as a résumé of the theories adopted by one school of thought. Much of the subject matter of the book has appeared in article form in various medical journals since 1911; and the impression is forced upon the reader conversant with these publications that Dr. Jordan has learnt but little from the great radiological experience which he has undoubtedly enjoyed during the intervening years. In nearly every chapter which deals with the radiological aspect of his subject will be found early observations on the normal and abnormal appearances which are of the greatest interest and value; but these are generally followed by deductions to which the later experience of other workers lends but little support. A particularly unfortunate chapter is that on the pelvic colon: the author here enumerates cases of disseminated sclerosis, epilepsy, fibroid phthisis, Dupuytren's contraction, etc., in which elongation of the pelvic colon was present; and the reader is invited to accept as a fact that the colonic abnormality provides the causal factor in the production of these lesions, no attempt whatsoever being made to advance proofs of these startling assertions.

A chapter on the treatment of stasis is of considerable interest. The author lays great stress on the value of the Curtis belt, combined with the administration of liquid paraffin, belladonna, and colloidal kaolin, and emphasizes the importance of correct diet. He considers that surgical intervention is only required for rectifying the secondary consequences of stasis, and in those cases where the large bowel is diseased beyond repair.

Selections from the Works of Ambroise Paré: With Short Biography and Notes. By DOROTHEA WALEY SINGER. Crown 8vo. Pp. 246, illustrated. Medical Classics Series. 1924. London: John Bale, Sons & Danielsson Ltd. 12s. 6d. net.

ALL lovers of the classics of medicine have every reason to be thankful to Mrs. Singer. She has added a very delightful book on Ambroise Paré to the series of Classics of Medicine edited by her distinguished husband. Of course, classics of medicine may be dull, just as all classics may be dull; but Paré is of unfailing

interest. His life and his work and his character will always attract the minds and the hearts of good judges of mankind. He lived in times which were full of passion and adventure; he was surgeon to four Kings of France, and to a host of the nobility, and gentry, and poor folk; his adventures in practice, especially in military service, and his discoveries and theories, will never be dull. Besides, his pleasant character, his humour, his love of his country, his enjoyment of the evident privileges of his existence, from good wine up to religion, stand out as clearly as any of his adventures and theories. Altogether he was a most lovable man.

It must have been hard work for Mrs. Singer to resist the temptation to rhapsodize over him; but she has done well to give more attention to his writings than to his home life, his services to the Royal Family and the Court, and so forth. He attended each of that brood of sons whom Catherine de Medici bore to Henri II, and he "held his cup straight", Huguenot though he was, through all the intricacies of that Court. Mrs. Singer wisely says that the question of Paré's religion never has been, and probably never can be, entirely decided: "for the truth is that he was neither fully Catholic nor fully Huguenot, but a devout and simple-hearted lover of God and man, who went his way and did his work according to such light as was given him, avoiding, as far as was possible, in those evil days, all the hatreds and envies that the name of religion inspired".

Only two criticisms of this book are possible. Mrs. Singer has kept the old-world spelling of Johnson's translation of Paré's works: perhaps she has done well; but it is hard to see why we have modernized Shakespeare if we are to be held down to the Elizabethan spelling of Johnson. The only other criticism is in regret that she has not used the portrait of Paré which Le Paulmier published in his Life of Paré. It is a charming portrait. Anyhow, here is a good book, worthy of buying and studying. It is a great pity that the old Harveian and Hunterian Orations are tied down to the pious commemoration of two men and no more. Long ago the original spirit of these Orations flickered out. The authorities ought to arrange for the praising of famous men in order of time. Ambroise Paré, most certainly, ought to be recalled to the gratitude of all our profession, and of all men who love a good life well lived. Meanwhile, let us congratulate Mrs. Singer on this excellent book about him.

The Treatment of Fractures in General Practice. By C. Max Page, D.S.O., M.S., F.R.C.S., Senior Surgeon to Out-patients, St. Thomas's Hospital, and W. Rowley Bristow, M.B., B.S., F.R.C.S., Surgeon to the Orthopædic Department, St. Thomas's Hospital. Demy 8vo. Pp. 239 + xi, illustrated. 1923. London: Oxford Medical Publications. 12s. 6d. net.

This handbook sets out to assist the general practitioner in the treatment of fractures, and in our opinion fulfils its object. The chapters dealing with general principles of treatment are clear, and in most cases give sufficient detail to be of practical value. A book emanating from St. Thomas's Hospital is certain to advocate the employment of plaster-of-Paris more generally than would be the custom of many surgeons, but even those who do not favour the use of plaster could take no great exception to its employment as advocated in this volume. In this connection we doubt whether the single plaster-of-Paris spica as depicted on page 150 would maintain abduction of the limb, as in our experience tilting of the pelvis will occur unless both thighs are held in plaster. In some instances it is our opinion that the authors are sanguine as to the results likely to be obtained from splint treatment. As an instance, the advice given for the treatment of fractures of the upper third of the femur will serve: it has not been our experience that such fractures can be adequately reduced by such methods as are here advised, or by immobilization in a Thomas's splint. We hold that it is important that the practitioner should be warned that, in such positions as these, splint treatment of a fracture is likely to be unsatisfactory, and that operative treatment should at least be considered without undue delay. We are glad to note that in dealing with

fractures of the lower end of the humerus the authors point out that the so-called 'separated epiphysis' is usually a fracture; but surely the same lesion is referred to on page 58 as a separation of the epiphysis. Is it correct to state that in fracture of the neck of the scapula there is lengthening of the arm? We have found this statement in other books as well as the one under review, but to us it has appeared impossible. Again, we find that fracture of the surgical neck of the humerus is a common accident; yet we have come to believe that the common fracture occurs considerably above the level of the surgical neck, and our opinion is confirmed by the photograph of the X ray which is intended to exemplify a fracture of the surgical neck. We should have liked to see greater stress laid upon the importance of rest and general treatment in fracture of the base of the skull, and consider the space given to fractures of the lower jaw scarcely adequate.

The diagrams are good, and the reproductions of X-ray photographs unusually clear, while the general finish of the volume is in keeping with the good level of the Oxford Medical Publications.

Surgical Emergencies. By RUSSELL HOWARD, C.B.E., M.S., F.R.C.S., Surgeon, London Hospital; Senior Surgeon, Poplar Hospital. Crown 8vo. Pp. 216 + viii, illustrated. 1924. London: Edward Arnold. 7s. 6d. net.

MR. RUSSELL HOWARD has undertaken a very difficult and exacting task in setting forth in the limited space of 200 pages "the methods of arriving at a diagnosis and the details of the operation to be performed in all the surgical emergencies with which a surgeon is likely to be confronted". He has covered a very wide field, and as a record of many years of experience in emergency surgery the book is of considerable value. It would appear, however, to be well-nigh impossible to include the many small but all-important technical details necessary for the guidance and safety of his junior colleagues, although he has attempted to do this in so far as the space at his disposal would permit.

The book commences with concise practical directions for dealing with hæmorrhage, and passes on to the consideration of shock. The treatment of shock leaves a good deal to be desired, and the views expressed on its pathology do not accord with the doctrines of modern physiology. Wounds of the limbs are dealt with in detail, and the next five chapters are devoted to acute abdominal lesions, intestinal obstruction, and the after-treatment of abdominal operations. This is the best section of the book, and great stress is laid upon the importance of rest and sleep and all measures to obtain these, as opposed to stimulant treatment, in the management of post-operative abdominal cases.

The final chapters deal with emergency conditions met with in the surgery of the urethra, of the head, of the neck, and of the thorax and spine, the last chapter giving a brief account of the most important lesions of the ear and eye likely to call for immediate operation.

There are several points which call for criticism. Some of the operations described—for example, the more elaborate methods of treating fractures, and the radical mastoid operation—can scarcely be considered as emergencies. Some of the measures suggested—for instance, excision of a gastric ulcer as an alternative to suture after acute perforation—though safe in the hands of the author, might be dangerous if attempted by his junior colleagues. The illustrations are poor on the whole, and some of them are distinctly misleading, and do not illustrate what is described in the text. The picture of suprapubic puncture shows the cannula inserted midway between the pubes and the umbilicus; and the picture of subtemporal decompression shows a left-sided bone defect which, if the operation were carried out as illustrated, would lead to a disastrous result. These minor mistakes, of which there are many in the book, coming from the pen of so well known a surgeon and teacher as Mr. Russell Howard, must not be allowed to pass without comment.

Radium, X Rays, and the Living Cells: with Physical Introduction. By HECTOR A. COLWELL, M.B. (Lond.), D.P.H. (Oxford), Assistant Radiologist, King's College Hospital; and SIDNEY RUSS, D.Sc. (Lond.), F.Inst.P., Joel Professor of Physics, Middlesex Hospital Medical School. Revised and enlarged edition. 1924. London: G. Bell & Sons Ltd. 21s. net.

THE authors of this text-book, which first appeared in 1915, rendered pioneer service to the subject of 'radio-biology' in producing it. It is always a difficult task to catch the first early outlines of a nascent science and to fix them in the framework of a text-book. That the attempt was successful is shown by the present revised and enlarged edition. The appearance of this work was significant in another aspect. It was one of the earliest products of close co-operation with a common aim between a medical man and a pure scientist. It seems likely that the future advance of medicine will increasingly depend upon such partnerships.

It is hardly necessary to enter into a detailed criticism of this well-known work. It opens with a physical section, doubtless contributed by Professor Russ, in which the fundamental facts about radium and X rays are stated authoritatively in a form intelligible to the non-physicist. In the later portions of the book the present state of our knowledge in regard to the effects of radiation upon living tissues, and especially upon neoplastic tissues, is fully set forth.

In the present edition the scope of several chapters has been extended to include recent experimental results, and a new chapter summarizes the action of radiation on living structures, and discusses the theories put forward to account for the observed results. A practical chapter upon the precautions to be taken by those habitually exposed to radiation might usefully have been added. In discussing secondary X rays the authors say, "Now that some of the fundamental properties of secondary X rays are known, it is highly probable that efforts may be directed towards their use". It seems strange that they do not mention the method of bismuth injection preparatory to X-radiation which was employed in the treatment of malignant disease, not without success, until the discovery of radium superseded it. The value of *Plate II*, an X-ray photograph by means of a crystal of zinc blende, would have been enhanced by a fuller description.

Apart from these criticisms on points of detail, we have nothing but praise for the book. It is indispensable to all surgeons interested in the therapeutic uses of radiation.

Collected Papers of the Mayo Clinic. Vol. XIII, 1921. Edited by MRS. M. H. MELLISH. Pp. 1318, illustrated. London and Philadelphia: W. B. Saunders Co. Ltd. 60s. net.

THOUGH the personnel of the Mayo Clinic has considerably increased since their new offices were completed, it is nevertheless a matter for congratulation that not only the volume but also the quality of the literature put out from the clinic maintains the high level of the early publications. We are glad to note that Dr. William Mayo looms more largely in this volume than in the last. Since the war the character of his papers has undergone some change. We have here, it is true, two of purely clinical interest on the surgery of the spleen, but that on hepatic insufficiency breaks new ground, and as it is now realized that comprehension of the functions of vital organs is necessary if we are to understand their pathology when involved in disease, there can be no doubt that these papers will be often referred to. This paper, the second Murphy Oration, details many interesting facts in the career of that brilliant surgeon, and it is in this appreciation of the works of others, as is also seen in that of Henry Jacob Bigelow, read before the Boston Surgical Society, that the generosity of thought that pervades all his writings is most apparent. Dr. Mayo has recently broken out in another direction, for his address on "The Medical Profession and the Public" shows how one who has made a world-wide reputation as a surgeon may also develop valuable qualities as a publicist. The Mayo Clinic have placed the wealth of their experience without stint

at the service of the world; surgeons in other countries with one per cent of the cases seen in the clinic have for their instruction details of the practice, both in preparation, operation, and after-treatment, which can save them from many difficulties and possibly fatalities; thus Waltman Walters' paper "On the Preparation of Patients with Obstructive Jaundice" is typical of one of the most valuable results of so large an operative and collated experience.

The more purely scientific papers range over so wide a field that it is scarcely possible for anyone interested in any aspect of medicine to open the volume without finding something which it will profit him to read. The investigations by Georgine Luden on "Blood Cholesterol" open out a most important field in the relation of this substance to cancer research. There is no doubt that a very large amount of experimental work is summarized in Williamson and Mann's "Experimental Study of Post-operative Peritoneal Adhesions". It should help others experimenting in this field, for they have convinced themselves that all the substances hitherto employed have been useless in preventing adhesions; and in recommending a gum-acacia-gelatin mixture as affording the best chance of preventing adhesions, they acknowledge certain difficulties in its use which they have not been able to overcome. Finally, we would like to draw attention to Rosenow's Mayo Foundation Lecture on "Focal Infection", which is remarkably stimulating in idea, and if pursued to its obvious ends in the clinical field may have very far-reaching consequences.

Excursions into Surgical Subjects. By JOHN B. DEAVER, M.D., Sc.D., LL.D., F.A.C.S., Emeritus Professor of Surgery, University of Pennsylvania; and STANLEY P. REIMANN, M.D., Assistant Professor of Experimental Pathology, University of Pennsylvania. 8vo. Pp. 188, illustrated. 1923. London and Philadelphia: W. B. Saunders Co. Ltd. 21s. net.

DR. DEAVER is one of the most versatile and prolific of authors, and one of the most expert of living surgeons. When vast experience is combined with sane judgement, with an acute sense of the fitness and the worth of things, and with a gift of frank and lucid expression, a man's influence becomes world-wide. There are few surgeons who equal Dr. Deaver in any of these attributes. Everything he writes is deserving of our serious attention.

This little book contains a series of papers written during the last few years, and several lectures delivered at Washington University. It is convenient to have them bound together for easy reference. Throughout all the chapters we find freshness of experience rather than originality of thought. There is no intellectual challenge; no provocation comes from the statement of new truths; but a delight is roused within us when we listen to a clear and candid examination of the old truths newly illustrated.

The lecture upon jaundice contains an interesting summary of the views held with regard to this symptom by the French writers and others. Chauffard's name, on page 60, appears twice as Chaufford. Few surgeons will agree with Dr. Deaver when he asserts (p. 61) that Hanot's cirrhosis is possibly the final stage of Banti's disease. W. J. Mayo doubts the existence of Hanot's cirrhosis. It is more than probable that Hanot described both biliary cirrhosis and hæmolytic jaundice under the one heading. The term Banti's disease is better reserved for the final stage of splenic anæmia. It has no connection, even of the remotest kind, with Hanot's cirrhosis, however we may interpret that disease.

In the lecture on diseases of the gall-bladder a classification of cases is introduced which appears to us to be strained and artificial. The preference for removal of the gall-bladder rather than its drainage will have the support of all surgeons to-day. The "Trials, Tribulations, Joys of a Surgeon" make a very interesting lecture.

The final chapter is headed "Living Pathology". Throughout the volume a reference here and there is made to 'living pathology'. The phrase 'the pathology

of the living' was introduced into surgery many years ago by Moynihan. The thought that he desired to illustrate is not indicated by a change of his phrase into 'living pathology'. Pathology is not a state of the tissues, but is a science; and the term 'living pathology', if it means anything, surely signifies that this science is vital, active, and growing. That is not what Dr. Deaver intends, however true it may be. His meaning is Moynihan's meaning.

Dr. Stanley Reimann contributes a few sections to the book, all of them of interest and value.

La Pratique Chirurgicale Illustrée. By VICTOR PAUCHET. Fascicule IV. Octavo. Pp. 250, with 307 illustrations. 1923. Paris: Librairie Octave Doin. 25 francs net.

THIS is the fourth portion of an Illustrated Practical Surgery, the previous portions of which have been reviewed in this JOURNAL.

The present volume deals with the surgery of the breast, duodenal ulcers, biliary passages, appendix, some diseases of the rectum, and some operations upon the uterus and appendages. The book is characterized by most profuse illustrations depicting the various stages of different operations. These illustrations are very good, and no doubt will be useful to many.

Die Chirurgie des Anfängers. By DR. GEORG AXHAUSEN, Professor of Surgery in the University of Berlin. 1923. Berlin: Julius Springer. 4·50 dollars.

THE best form of preliminary instruction in medicine and surgery is one of the questions which is giving rise to much thought in medical schools to-day. It is frankly admitted that our present methods are not satisfactory, and in consequence it is of interest to look and see what is being done in other countries. Professor Axhausen has written a book of 440 pages, well bound and illustrated. It comprises three chapters—on general surgical principles, methods of examination of special parts, and the principles of operative surgery. The book is good of its kind, but it does not yet satisfy the wants of the student who wishes to learn medicine as a science and not as a craft.

Chirurgie de la Tête et du Cou. By CH. LENORMANT and P. BROCQ. Sixth edition. Crown 8vo. Pp. 338 + viii, with 245 illustrations. 1923. Paris: Masson et Cie.

THIS book, one of a series of seven volumes entitled " Précis de Technique Opératoire ", has reached its sixth edition, the first having appeared in 1904. It embraces a surprising medley of operations, ranging from removal of the Gasserian ganglion to the extraction of a wisdom tooth. The steps of each operation are briefly related, and are illustrated, in many instances remarkably well, by a large number of semi-diagrammatic pictures.

For a student wishing to refresh his memory before an examination, the little book should prove valuable, but one can scarcely agree with the opinion expressed in the preface that every practitioner ought to know how to carry out these operations, " since the practice of surgery is no longer confined, as formerly, to the hands of a chosen few ". There would not be many who would care to entrust to the average doctor such procedures as hypophysectomy, laryngectomy, or excision of the cervical sympathetic, nor would many general practitioners be prepared to carry out the removal of a cerebellar tumour through an osteoplastic craniotomy. On the other hand, the accounts of such operations as tracheotomy, mastoid antrotomy, and the like, clearly described and well illustrated as they are, give the book a reasonable claim to a place in the general practitioner's library.

Les Ulcères de l'Estomac et du Duodénum. By ED. ENRIQUEZ and GASTON DURAND. Crown 8vo. Pp. 184, illustrated. 1923. Paris: Masson et Cie. 10 francs net.

THIS small volume concerns itself with diagnosis. After a brief historical account, the book is divided into two parts: (1) Diagnosis of the lesion; (2) Diagnosis of the seat of the ulcer. It is a book of value in that it gives the views of our French colleagues on diagnosis and methods of examination.

Traumatismes du Poignet et Rayons X. By ETIENNE DESTOT, Lyon. Royal 8vo. Pp. 174, with 184 figures. 1923. Paris: Masson et Cie. 16 francs net.

THIS is the posthumous work of Destot, which was finished by him, but not published, in 1918, a little before his death. In this book attention is called to the injuries of the wrist which previously were little known or studied, and the matter is dealt with altogether in an admirable style. The only criticism is with the printing of the skiagrams. These are generally useless, owing to the inferior quality of the paper and the method of reproduction, which completely spoil a good monograph.